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Y-12

OAK RIDGE Y-12 PLANT

MARTIN MARIETTA

A REVIEW OF THE Y-12 PLANT DISCHARGE OF ENRICHED URANIUM TO THE SANITARY SEWER (DEUSS)

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Environmental Management Department
Health, Safety, Environment, and
Accountability Division

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MANAGED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

Y/TS-776

A REVIEW OF THE Y-12 PLANT DISCHARGE OF ENRICHED URANIUM TO THE SANITARY SEWER (DEUSS)

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U.S. DEPARTMENT OF ENERGY
Under Contract No. DE-AC05-840R21400

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DEFINITIONS

Agreement State - any State with which the Nuclear Regulatory Commission or the Atomic Energy Commission has entered into an effective agreement under subsection 274b of the Atomic Energy Act of 1954.

Assay - qualitative or quantitative determination of the components of a material, as an ore or a drug.

Concentration - in solutions, the mass, volume, or number of moles of solute present in proportion to the amount of solvent or total solution.

Criticality - the condition in which a nuclear chain reaction is self-sustaining.

Curie - a unit of radioactivity, defined as that quantity of any radioactive nuclide which has 3.7E10 disintegrations per second.

Effluent - the liquid waste of sewage and industrial processing.

Enrichment - a process that changes the isotopic ratio in a material; for uranium the ratio of U-235 to U-238 may be increased by gaseous diffusion of uranium hexafluoride. The isotopic enrichment of U-235 is usually expressed in weight per cent.

Enriched uranium - uranium with an assay greater than 0.711 weight percent (i.e., the ratio of U-235 to total uranium is greater than 0.711%).

Source material - uranium or thorium, or any combination thereof, in any physical or chemical form; ores which contain by weight one-twentieth of one percent (0.05%) of uranium, thorium or any combination thereof. Source material does not include special nuclear material.

Special nuclear material - plutonium, uranium 233, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the Nuclear Regulatory Commission or Atomic Energy Commission, pursuant to the provisions of section 51 of the Atomic Energy Act, determines to be special nuclear material; any material artificially enriched by any of the foregoing , but does not include source material.

ACRONYMS

CFR - Code of Federal Regulations

DEUSS - Discharge of Enriched Uranium to the Sanitary Sewer

DOE - Department of Energy

l - liter

mg - milligram

MGD - Million Gallons per Day

NRC - Nuclear Regulatory Commision

pCi - pico-Curie

POTW - Publicly Owned Treatment Works

RCRA - Resource Conservation and Recovery Act

SNM - Special Nuclear Materials

TSCA - Toxic Substances Control Act

ug - microgram

I. EXECUTIVE SUMMARY

A review of the Y-12 Plant discharge of enriched uranium to the sanitary sewer (DEUSS) was conducted by a team of individuals from various organizations throughout the plant. This study was initiated in early June 1991 and expanded to review other special nuclear materials (SNM) which originate from the Y-12 Plant sanitary sewer and ultimately reach the city of Oak Ridge publicly owned treatment works (POTW).

The project team identified the average amount of total uranium leaving the Y-12 Plant as being approximately 23 gram/day during 1990. The average amount of U-235 being discharged off site from the Y-12 Plant was less than 1 gram/day. Measurement of total uranium and U-235 at the City Monitoring Station, which includes the Union Valley Industrial Park, indicated an average release of approximately 38 gram/day and less than 1 gram/day, respectively. By comparison, the city Of Oak Ridge POTW could be expected to have approximately 5000 grams of total uranium at any one point in time, assuming a 20% increase for unknown source input into the POTW facility. The levels of U-235 existing in the POTW for the same time frame could be expected to range from 40-50 grams, which also included an allowance for unknown input. This calculated to be an enrichment level of between 0.80% and 1.00% which agreed with the analysis of sludge samples taken from the POTW. It was noted that the amount of total uranium discharged through the sanitary sewer decreased over the past year, while the assay of enriched uranium steadily increased.

Since data was not initially available to suggest the amount of plutonium and U-233 leaving the Y-12 Plant on a daily basis, additional sampling was performed. It was found that sub pico gram quantities of plutonium and U-233 were being discharged through the sanitary sewer on a daily basis for the time period analyzed. This represents values which are not of concern. (Testing frequency of the sewer effluent was previously conducted on a monthly basis; however, the project team recommended that this be changed to reflect a weekly sampling, which is now being implemented.)

It is the position of this project team and the Office of General Counsel that the Y-12 Plant complies with applicable technical regulations governing off-site releases of SNM through the sanitary sewer. It is also the position of this team and the Office of General Counsel, that the city of Oak Ridge may be in need of an exemption from licensing requirements from the state of Tennessee to continue handling the current low levels of special nuclear materials.

II. INTRODUCTION

The Oak Ridge Y-12 Plant is situated adjacent to the Oak Ridge city limits and is operated by the United States Department of Energy (DOE). The Y-12 Plant is located on 4,860 acres, which is collectively referred to as the Y-12 Plant site. Among the missions for which the facility is in existence are producing nuclear weapons components, supporting weapon design laboratories, and processing special nuclear materials (SNM).

Recently, there has been increased interest in the conveyance of SNM. This was brought about by the discovery that Rollins Environmental Services Co., a commercial waste management company located in Louisiana, received some material from the Department of Energy that contained uranium enriched to levels above that at which uranium naturally occurs (assay of approximately 0.71%). The company did not possess the required permits to handle the SNM and, consequently, all shipments of solid waste were halted to this company.

The Y-12 Plant is under the regulatory guidance of DOE Order 5400.5 and has complied with the technical requirements governing SNM since its issue. However, an in-depth review with appropriate documentation had not been performed, prior to the effort presented herein, to substantiate this claim. As a result of the solid waste issue, it was determined that other types of waste should be formally reviewed for content with respect to SNM. Therefore, a project was formed to investigate the conveyance of SNM through the sanitary sewer system. **It is emphasized that this project addresses only effluent from the sanitary sewer system and not the storm sewer system.**

The project reviewed sanitary sewer data both for the Y-12 Plant and the Y-12 Plant site. The distinction is made for the reason that the sanitary sewage originates from two sources. Therefore, it is necessary to identify the separate entities. The Y-12 Plant includes only discharges from this facility. The Y-12 Plant site includes effluent contributions from both the Y-12 Plant and the Union Valley Industrial Park. Data representative of the Y-12 Plant site is collected at the City Monitoring Station. Monitoring performed on the Union Valley Industrial Park line allows back calculation of the actual Y-12 Plant contribution.

III. HISTORICAL DEVELOPMENT OF SNM ISSUE

SNM is defined in the Code of Federal Regulations, 10 CFR 70 as: "(1) Plutonium, uranium 233, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the Commission, pursuant to the provisions of section 51 of the Act, determines to be special nuclear material, but does not include source material; or (2) any material artificially enriched by any of the foregoing but does not include source material."

On May 17, 1991, the DOE issued a memorandum concerning the "Shipment of Waste Originating in Radiation Control Areas." The memorandum directed that all shipments cease to commercial facilities, not licensed by the Nuclear Regulatory Commission or an Agreement State, of any RCRA-hazardous or TSCA-regulated waste originating in a radiologically controlled area. In addition, questions were raised inquiring about control over sanitary waste originating in a radiologically controlled area and subsequently sent to an off-site landfill or a publicly owned treatment works (POTW). Based on this information, additional correspondence was generated by Martin Marietta Energy Systems, Inc., stating that no off-site waste shipment (liquid or solids) should occur if it contained uranium with known or suspected enrichment above 0.711 percent U-235, plutonium above background levels, known or suspected technetium-99, or concentrations of any other radionuclides not specifically exempted by NRC by-product or source material regulations, unless the receiving disposal site had the appropriate permits.

A documented study of the SNM issue with respect to the Y-12 Plant was initiated in response to the letters stated above. A project team was assembled to address this issue and consisted of Y-12 Plant representatives from Nuclear Criticality Safety Department, Development Division, Environmental Management and Health Physics Departments, Y-12 Plant Laboratory, Quality (statistician), Waste Management, and Maintenance and Utilities Divisions. The DOE was also represented by site personnel and provided oversight and strategic guidance. Prior to the initial meeting of the project team, Martin Marietta Energy System HSEA personnel briefed Energy Systems public relations personnel representing the Y-12 site complex to apprise them of the upcoming issue.

IV. PROJECT TEAM APPROACH

The project team first convened on June 7, 1991. Detailed minutes of this meeting were taken and distributed to each team member. The goal, charter, and issues of the project are given in Appendix A and includes additions that resulted from the presentations given in later meetings.

Additional project team meetings were held on June 10, 14, and 17 to discuss information and data that had been assimilated. As a result of these and other gatherings, discussions addressing the regulatory and technical concerns are presented in Sections V and VI entitled "SNM REGULATORY CONSIDERATIONS" and "TECHNICAL OVERVIEW," respectively.

V. SNM REGULATORY CONSIDERATIONS

Regulations governing SNM are of primary consideration since they govern the responsibilities of facilities who handle, process, or manage SNM. The project team employed the services of two individuals knowledgeable in the field of Nuclear Regulatory Commission (NRC) regulations as outside industry consultants. In addition, the Office of General Counsel was consulted for guidance and concurrence.

Based on input from these individuals, as well as that of the project team, the following information has been assimilated to reflect the interpretations made of guidance given in the federal and state regulations.

A. Code of Federal Regulations

1. 10 CFR 70 - Domestic Licensing of SNM

The license requirements delineated in this regulation (excerpts provided in Appendix B) do not apply to the DOE since it is specifically exempted. The city of Oak Ridge is also exempted from the provisions herein since the state of Tennessee is an Agreement State with the NRC. Therefore, the city of Oak Ridge is bounded by 10 CFR 150.

2. 10 CFR 20 - Standards for Protection Against Radiation

The license requirements provided in this regulation (excerpts provided in Appendix C) do not apply to DOE as it is specifically exempted and is not considered a licensee. However, it does provide for a comparison of the release of certain radionuclides. The limits set forth in this code are reiterated in the state of Tennessee regulations, Chapter 1200-2-5-.18.

3. 10 CFR 150 - Exemptions and Continued Regulatory Authority in Agreement States and in Offshore Waters Under Section 274

The license requirements stated in this regulation (excerpts provided in Appendix D) apply to the city of Oak Ridge and impose criteria concerning the amount of SNM that is acceptable for handling before an SNM license is required by the holder. As shown in Section VI.D., the city of Oak Ridge is estimated to have much less than the permissible value of U-235.

B. State of Tennessee Regulations

Chapter 1200-2-5-.18 - Standards for Protection Against Radiation

The license requirements stated in the regulation (excerpts provided in Appendix E) do not apply to DOE. Like 10 CFR 20, this is not applicable to the issue at hand. Still, it provides for a measurement of the discharge of radionuclides from the Y-12 Plant site.

VI. TECHNICAL OVERVIEW

The technical considerations for a project of this magnitude are numerous. The following paragraphs will address various aspects, especially the thought processes used to arrive at the end conclusion.

A. Description of the Y-12 Plant Site Sanitary Sewer System

Diagrams of the sanitary sewer system depicting both detailed and general layout are shown in Appendix F. Summarizing, there exists a west line and an east line from the Y-12 Plant which feed into the main line that exits the plant site. In addition, the Union Valley Industrial Park sewage feeds into the main line on the Y-12 Plant site and contributes additional effluent which must be accounted for. In the past, monthly testing has been performed at the City Monitoring Station (exit station), which is located on the off-site edge of the Y-12 Plant site, and at the Union Valley line just prior to its juncture with the Y-12 Plant site line. With these two points, a back calculation can be performed to assess the contribution from the Y-12 Plant.

The monthly flow measured at the exit station given in the data in Appendix G indicates an average of 1.44 million gallons per day (MGD). The average flow for the year 1989 is 1.08 MGD, while the average flow for the year 1990 is 1.66 MGD. These numbers include both Y-12 and Union Valley contribution. Experience and actual figures place the Y-12 contribution between 0.8 and 1.0 MGD.

B. Measurement of SNM from the Y-12 Plant Site (City Monitoring Station)

Total uranium effluent concentrations flowing off the premises of the Y-12 Plant site, including Union Valley, measured at the City Monitoring Station over the time span given in Appendix G, has been analyzed as given below:

	Minimum	Maximum	Average
Total U	0.002 mg/l	0.127 mg/l	0.017 mg/l
	0.014 lb/day	1.277 lb/day	0.19 lb/day
	7 gram/day	618 gram/day	86 gram/day

The average concentration of total uranium flow off site for year 1990 was 0.006 mg/l. The average amount was 0.084 lb/day (38 gram/day). Actual data from Appendix G indicating gram/day estimates an average to be 41 gram/day for year 1990. This discrepancy may be attributed to round-off error at these small values.

Uranium-235 measured as a percentage of the values given in Appendix G for total uranium ranged 0.25% to 2.4% with an average of 0.91%. Actual weight values for U-235 carried off-site are as follows:

	Minimum	Maximum	Average
U-235	0.0001 lb/day	0.0033 lb/day	0.0009 lb/day
	0.06 gram/day	1.61 gram/day	0.45 gram/day

The average percent U-235 of total uranium for the year 1990 was 1.15%. The average amount carried through the sanitary sewer system for 1990 was 0.0007 lb/day (0.32 gram/day). Actual data from Appendix G indicates gram/day estimates of 0.35 gram/day. This discrepancy may be attributed to round-off error at these small values.

Samples of effluent were taken from the City Monitoring Station to determine the presence of U-233. Initial results indicated none of this constituent above background levels was present (see Appendix H). Further, more sophisticated testing revealed only trace amounts.

The presence of plutonium was also revealed in the sanitary sewer effluent as shown by the results in Appendix H. These trace amounts are considered insignificant when compared with the total release of radionuclides from the Y-12 Plant (see Appendix N).

C. Measurement of SNM from the Y-12 Plant

Total uranium flow from the Y-12 Plant itself as provided in excerpts from the 1988, 1989, and 1990 Environmental Surveillance Reports (see Appendix I) place minimum, maximum, and average concentrations as follows:

Year	Minimum	Maximum	Average
1988	0.002 mg/l	0.023 mg/l	0.011 mg/l
1989	0.004	0.035	0.013
1990	0.001	0.013	0.006

U-235 measured as a percentage of total uranium for the same time period above reveals:

Year	Minimum	Maximum	Average
1988	0.72%	5.43%	1.71%
1989	0.89	6.96	2.33
1990	1.07	6.30	1.97

Based on a flow rate of 1.0 MGD from Section VI.A, these concentration values for total uranium and percent U-235 translate into the following weight measurements in lb/day:

	Year	Minimum	Maximum	Average
Total U	1988	0.017	0.192	0.092
	1989	0.033	0.292	0.108
	1990	0.008	0.108	0.050
U-235	1988	0.00012	0.01043	0.00157
	1989	0.00029	0.02032	0.00252
	1990	0.00009	0.00680	0.00099

Using data for year 1990, the maximum total uranium leaving the Y-12 Plant equals approximately 50 gram/day. The average equals approximately 23 gram/day. Assuming these same parameters to govern the amount of U-235 leaving the Y-12 Plant results in a maximum of approximately 3 gram/day and an average of approximately 0.5 gram/day.

Since U-233 and plutonium are not handled or produced by other industries in the immediate geographic area, it is reasonable to assume that the measurements for these constituents as given in Section VI. B. are representative of the Y-12 Plant

contribution. Based on the infinitesimal discharges of these metals as shown in Appendix H, compliance with regulatory guidelines will not be impacted (see Appendix N).

D. Measurement of SNM at the City of Oak Ridge POTW

The city of Oak Ridge POTW is designed to treat an estimated 5.2 MGD effluent flow. Although no formal program has been established to monitor the amount of SNM actually being handled at the facility, a monitoring program has been in place for some time to detect the radioactivity level in the outgoing sludge resulting from the presence of total uranium and U-235. This has been performed in an effort to remain cognizant of the sludge content, since the entire amount generated by the POTW is placed back on the DOE Reservation. Also, as a result of contamination to the facility during the mid-1980s from other industrial users not associated with the DOE Field Office, Oak Ridge (formerly Oak Ridge Operations), monitoring of the POTW was initiated to determine the levels of certain radionuclides other than uranium.

Based on information obtained about the design of the POTW, the project team performed mass balance calculations to determine the amount of uranium and U-235 that could be expected to reside in the treatment system at any one point in time (see Appendix J). (SNM metals U-233 and plutonium were not specifically included since the presence of these constituents have historically been shown to be infinitesimal or absent from the effluent stream emanating from the Y-12 Plant.) Results from this mass balance indicate an amount of total uranium of less than 5000 grams with a content of less than 40 grams U-235. This approximates an assay of 0.80%. Additional data gathered by the project team (see Appendix K) revealed that for year 1990, assays ranged from 0.62% to 0.87% in the sludge that was monitored as described above.

Because of the limited data that existed, the project team decided that it would be beneficial to monitor concurrently the effluent from the Y-12 Plant site, the influent that was received by the POTW, and the effluent generated by the POTW that entered East Fork Poplar Creek (see Appendix L). These results show that uranium leaving the Y-12 Plant site, as measured at the City Monitoring Station, is in greater concentration than when it arrives at the POTW. This would be expected because of dilution of the effluent stream. Also, the uranium concentration entering EFPC from the POTW are insignificant. Plutonium and U-233 were not measured since the predicted values were considered to be insignificant. This assumption was later verified, as discussed in Sections VI. B. and C.

In an effort to address the concern of nuclear criticality for the levels of enriched uranium at the POTW, the project team looked at the potential for this to occur. Based on the levels predicted, this was determined to be nonexistent (see Appendix M).

E. Calculation of Regulatory Compliance

The need to maintain compliance with regulatory standards dictates that calculations be performed to verify that this has been accomplished. As indicated in Section V, "SNM REGULATORY CONSIDERATIONS," DOE Order 5400.5, Code of Federal Regulations 10 CFR 20.303, and State of Tennessee Standard 1200-2-5-.18, contain limits for radionuclide discharges. The project team gathered data and performed calculations to address the technical guidelines contained therein (see Appendix N). It should be noted that the limits in the latter two regulations mentioned above are basically the same, although the calculations reference only the limits given in 10 CFR 20.

1. **DOE Order 5400.5** specifies concentration discharge limits for radionuclides (see Appendix O). With respect to uranium, U-235 and U-238 are defined to have the same limit for waste considerations (3E-6 uCi/ml). Using 1990 total uranium data for the Y-12 Plant, the discharge value is calculated to be approximately 7E-9 uCi/ml, which is well below the requirement.

   The maximum concentration value (0.127 mg/l) of total uranium taken from Appendix G and used with the corresponding flow rates results in a Y-12 Plant site concentration value of 1.47E-7 uCi/ml, assuming an enrichment level of 1.97%. This remains below the required limit of 3E-6 uCi/ml.

2. **10 CFR 20.303 and 1200-2-5-.18**, as stated before, are not applicable to DOE. However, for comparison purposes, the following chart was assembled to verify that the Y-12 Plant and Y-12 Plant site are below the daily rate of release limits for uranium, monthly concentration limits for uranium, and limits on the yearly release of total quantity of radionuclides.

Agency	Daily	Monthly	Yearly
Chapter 1200	3.03E6 uCi/day	8.4E-4 uCi/ml	1.0 Ci/yr
Y-12 Plant	2.63E1 uCi/day	7.0E-9 uCi/ml	0.4 Ci/yr
Y-12 Site	7.23E2 uCi/day	1.5E-7 uCi/ml	0.5 Ci/yr

A numerical comparison of Chapter 1200 criteria with the actual values for plutonium and U-233 is given in Appendix N, and is representative of a lack of cumulative data. However, a historical knowledge of the presence of these metals and the data presented in Sections VI. B. and C. and Appendix H, as well as Appendix N, indicates there would not be a concern.

One additional consideration that must be addressed is whether or not the radionuclides are considered to be "in solution or dispersed in water." The process by which microscopic particles of the materials enter the sewer system

is by way of: (a) laundry, (b) hand washing and other hygiene related activities, and (c) inflow and infiltration through degraded sewer piping. By nature, the radionuclides will be in solution as a result of contact and mixing with mass quantities of other constituents in the effluent stream. Dispersion in water is effected by the particle size and the concentration of radionuclide being dissipated through the aqueous solution.

F. Miscellaneous Technical Issues

1. **Does the following direction provided by the DOE apply also to the sanitary sewer? "Cease shipment to commercial facilities not licensed by the Nuclear Regulatory Commission or an agreement State of any RCRA-hazardous or TSCA-regulated waste originating in a radiologically controlled area until further notice."**

   The term "shipment" may be defined as transporting or causing to be transported. The sanitary sewer system is a conveyance and is considered to transport effluent from the Y-12 Plant to the city of Oak Ridge POTW. Based on the findings of the project team, the state of Tennessee is an "Agreement State" as specified in 10 CFR 150. Also, since it has been established that the city of Oak Ridge POTW handles less than the permissible limit given to be 350 grams of contained U-235, the city of Oak Ridge is considered not to be in need of a license from the NRC or the state of Tennessee. However, it is recognized that an exemption may be needed from the state of Tennessee in order for the POTW to continue its present sewage treatment operations. Based on this logic, there is no immediate need to cease conveyance of the sewage from the Y-12 Plant to the city of Oak Ridge POTW. (The existence of small amounts of other SNM that are discharged to the POTW do not represent quantities that would dictate further actions be taken, over and above that which was previously stated.)

2. **How does the Y-12 Plant assure that sanitary waste originating in a radiologically controlled area and sent to an off-site landfill or a POTW is controlled?**

   Sanitary waste originating in a radiologically controlled area is disposed of by various methods. At the present time, the project team is unaware of any plant processes associated with SNM that are directly tied to the sanitary sewer. Process waters are collected and treated and disposed of by other methods. SNM enters the sanitary sewer by way of employee hygiene facilities at radiation boundary control stations, at changehouses, and by inflow and infiltration into the sewer lines. There exists a possibility that other avenues are involved, but they remain unidentified. At present, the control measures include minimizing the possibility of exposure to the conveyance means (i.e., reduce the source

emissions as much as possible to diminish contact with the surrounding environment). There is also a program currently addressing rehabilitation of the sanitary sewer system that will help to correct the vast mounts of inflow and infiltration into the sewer system.

3. **What exemptions does the NRC Code of Federal Regulations provide to persons in Agreement States?**

   The 10 CFR 150 provides exemptions to persons in Agreement States from the regulations of the NRC imposing requirements upon persons who manufacture, produce, receive, possess, use or transfer by-product material, source, or SNM in quantities not sufficient to form a critical mass. For the purposes of this part, SNM not sufficient to form a critical mass means uranium enriched in the isotope U-235 in quantities not exceeding 350 grams of contained U-235, U-233 in quantities not exceeding 200 grams, and plutonium in quantities not exceeding 200 grams. Other regulations apply for a combination of these radionuclides, but at the quantity levels in this project, these criteria are not a concern. It is noted that there may be some requirement to be met from the Agreement State. It has been this project team's recommendation that the DOE aid the city of Oak Ridge in pursuing this matter.

4. **Does the Y-12 Plant monitor the city of Oak Ridge POTW for radiation contamination to workers on location?**

   The Y-12 Plant is not actively involved in a radiation monitoring program of the POTW. However, several programs have been administered in the past. In 1984, a program to monitor the POTW for radiation exposure to its workers resulted in the finding that the most likely pathway for risk of exposure was through the direct contact with the sludge that was produced or by inhalation of the air in the immediate vicinity of the sludge As a result, the workers were equipped with dosimetry devices for body monitoring. Also, elevated radioactive discharges from Quadrex HPS, Inc., resulted in extensive monitoring of the POTW for limited radionuclides. At the present time, according to Jack Robinson of the city of Oak Ridge POTW, eleven (11) points within the facility are currently being monitored with dosimetry devices. Also, the individual physically responsible for administering the sludge in the application program is equipped with a dosimeter.

5. **How accurate are analytical results received from the Y-12 Plant Laboratory?**

   The Y-12 Plant Laboratory measures concentrations of uranium by way of mass spectrometry and has an accuracy of $\pm$ 10%. Measurement of other radionuclides is variable and is concentration dependent.

6. **What is the concentration of U-235 in the cake of the POTW digesters?**

The city of Oak Ridge POTW currently in use came into operation in 1982. The cake in the digesters is not as pronounced as cake in digesters of an operation that has been in use for long periods of time (i.e., 20 years) and, therefore, would not be expected to promote extreme concentration levels. Measurement of the uranium content in the digester cake would not be an accurate representation of actual concentration levels since there would be no way to verify the homogeneity of the cake with respect to uranium (i.e., because one area is high or low does not mean that the entire cake would reflect consistency). This is different from that of the sludge being analyzed because of the liquid state and the greater opportunity for uranium to maintain uniformity within the sludge.

7. **What is the trend of uranium and U-235 leaving the Y-12 Plant?**

Appendix G indicates that the amount of uranium measured at the City Monitoring Station has decreased over the 1988 to 1991 time frame. The percent U-235 has increased at that location for the same time frame. Also, monitoring of the sludge at the city of Oak Ridge POTW shows clearly that the levels of uranium have been on the downward trend, while the percent U-235 has increased (see Appendix K). It is possible that the contributions of U-238 from the Y-12 Plant and/or Union Valley Industrial Park have decreased during this period while the levels of U-235 have remained the same or increased. This would account for the increased percentage levels of U-235.

8. **Are there other contaminants in the sanitary sewer that need to be identified and further investigated as a result of this project?**

The testing of the sanitary sewer effluent being discharged from the Y-12 Plant has historically been accomplished on a once per month basis. This may not truly represent an accurate picture as to the content that is being produced by the Y-12 Plant. Beginning July 12, 1991, a weekly sampling and analytical program was instituted to increase the awareness at the Y-12 Plant of the effluent content. Testing on this date for other radionuclides (including technetium, strontium, cesium, cobalt, and thorium) revealed no elevated levels (see Appendix H). Total uranium, U-233, U-235, plutonium, mercury and zinc will be regularly monitored in the weekly sampling and analytical program until further notice.

9. **How have ALARA requirements been addressed?**

Currently, the Y-12 Plant uses a number of plant standards and procedures which regulate various aspects of radiation protection. Also, a plan and schedule for implementing an environmental ALARA program over and above what already exists is in the process of being developed.

APPENDICES

APPENDIX A

GOAL

RESOLVE THE ISSUE OF DISCHARGING ENRICHED URANIUM AND OTHER SPECIAL NUCLEAR MATERIALS TO THE SANITARY SEWER, WHICH ULTIMATELY REACHES THE CITY OF OAK RIDGE PUBLICLY OWNED TREATMENT WORKS (POTW).

CHARTER

1. GATHER ALL PERTINENT FACTS AND RELEVANT DATA CONCERNING THE DISCHARGE OF URANIUM INTO THE SANITARY SEWER. EQUALLY IMPORTANT IS THE ASSIMILATION OF FACTS AND DATA ADDRESSING THE URANIUM CONTENT IN THE SLUDGE THAT IS PLACED BACK ON THE RESERVATION AFTER TREATMENT BY THE POTW.

2. DETERMINE WHAT THE APPLICABLE REGULATORY REQUIREMENTS ARE, HOW THEY APPLY TO THIS ISSUE, AND WHAT SPECIFIC ACTIONS NEED TO BE TAKEN.

3. MAKE RECOMMENDATIONS TO THE DEPARTMENT OF ENERGY OF ACTIONS NECESSARY TO RESOLVE THIS ISSUE.

4. ASSIST DOE IN THE IMPLEMENTATION OF THESE RECOMMENDATIONS.

ISSUES

1. ALL APPLICABLE REGULATORY CRITERIA REQUIRES DEFINITION.

2. THE CITY OF OAK RIDGE MAY NEED TO APPLY FOR AN NRC LICENSE TO TREAT/HANDLE/MANAGE SPECIAL NUCLEAR MATERIALS (I.E., ENRICHED URANIUM - ASSAY > 0.71%).

3. THE SANITARY SEWER APPLICATION MAY NOT ALLOW DOE TO DISCHARGE ENRICHED URANIUM TO THE CITY OF OAK RIDGE POTW.

4. THE RADIATION PROTECTION FOR WORKERS OF THE CITY OF OAK RIDGE REQUIRES FURTHER INVESTIGATION.

5. THE CONTENT OF ENRICHED URANIUM IN THE EFFLUENT SLUDGE FROM THE POTW MAY NEED TO BE FURTHER INVESTIGATED.

6. THE CONCERN OF NUCLEAR CRITICALITY SAFETY WRT THE POTW SHOULD BE REVIEWED.

7. A REVIEW FOR OTHER CONTAMINANTS (I.E., MERCURY AND ZINC) IS IN ORDER.

APPENDIX B

Compactors); the suitability of volume reduction equipment to the circumstances (specific activity considerations, actual volume reduction factors, generation of secondary wastes, equipment contamination, effluent releases, worker exposure, and equipment availability); and the administrative controls which could be applied, in making a determination whether waste to be delivered for disposal under this part has been reduced in volume to the maximum extent practicable using available technology.

§ 62.26 *Criteria for designating a disposal facility.*

(a) The Commission shall designate an appropriate non-Federal or regional disposal facility if an affirmative determination is made pursuant to §§ 62.21, 62.23, or 62.24 of this part.

(b) The Commission will exclude a disposal facility from consideration if:

(1) The low-level radioactive wastes of the generator do not meet the criteria established by the license agreement or the license agreement of the facility; or

(2) The disposal facility is in excess of its approved capacity; or

(3) Granting emergency access would delay the closing of the disposal facility pursuant to plans established before the receipt of the request for emergency access; or

(4) The volume of waste requiring emergency access exceeds 20 percent of the total volume of low-level radioactive waste accepted for disposal at the facility during the previous calendar year.

(c) If, after applying the exclusionary criteria in paragraph (b) of this section, more than one disposal facility is identified as appropriate for designation, the Commission will then consider additional factors in designating a facility or facilities including—

(1) Type of waste and its characteristics,

(2) Previous disposal practices,

(3) Transportation

(4) Radiological effects,

(5) Site capability for handling waste,

(6) The volume of emergency access waste previously accepted by each site both for the particular year and overall, and

(7) Any other considerations deemed appropriate by the Commission.

(d) The Commission, in making its designation, will also consider any information submitted by the operating non-Federal or regional LLW disposal sites, or any information submitted by the public in response to a FEDERAL REGISTER notice requesting comment, as provided in paragraph (b) of § 62.11 of this part.

Subpart D—Termination of Emergency Access

§ 62.31 Termination of emergency access.

(a) The Commission may terminate a grant of emergency access when emergency access is no longer necessary to eliminate an immediate threat to public health and safety or the common defense and security.

(b) The Commission may terminate a grant of emergency access if an applicant has provided inaccurate information in its application for emergency access or if the applicant has failed to comply with this part or any conditions set by the Commission pursuant to this part.

PART 70—DOMESTIC LICENSING OF SPECIAL NUCLEAR MATERIAL

GENERAL PROVISIONS

Sec.

EXEMPTIONS

Authority: Secs. 51, 53, 161, 182, 183, 68 Stat. 929, 930, 948, 953, 954, as amended, sec. 234, 83 Stat. 444, as amended (42 U.S.C. 2071, 2073, 2201, 2232, 2233, 2282); secs. 201, as amended, 202, 204, 206, 88 Stat. 1242, as amended, 1244, 1245, 1246 (42 U.S.C. 5841, 5842, 5845, 5846).

Sections 70.1(c) and 70.20a(b) also issued under secs. 135, 141, Pub. L. 97–425, 96 Stat. 2232, 2241 (42 U.S.C. 10155, 10161). Section 70.7 also issued under Pub. L. 95–601, sec. 10, 92 Stat. 2951 (42 U.S.C. 5851). Section 70.21(g) also issued under sec. 122, 68 Stat. 939 (42 U.S.C. 2152). Section 70.31 also issued under sec. 57d, Pub. L. 93–377, 88 Stat. 475 (42 U.S.C. 2077). Sections 70.36 and 70.44 also issued under sec. 184, 68 Stat. 954, as amended (42 U.S.C. 2234). Section 70.61 also issued under secs. 186, 187, 68 Stat. 955 (42 U.S.C. 2236, 2237). Section 70.62 also issued under sec. 108, 68 Stat. 939, as amended (42 U.S.C. 2138).

For the purposes of sec. 223, 68 Stat. 958, as amended (42 U.S.C. 2273); §§ 70.3, 70.7(g), 70.19(c), 70.21(c), 70.22 (a), (b), (d)–(k), 70.24 (a) and (b), 70.32 (a) (3), (5), (6), (d), and (i), 70.36, 70.39 (b) and (c), 70.41(a), 70.42 (a) and (c), 70.56, 70.57 (b), (c), and (d), 70.58 (a)–(g)(3), and (h)–(j) are issued under secs. 161b, 161i, and 161o, 68 Stat. 948, 949, and 950 as amended (42 U.S.C. 2201(b), 2201(i), and 2201(o)); §§ 70.7, 70.20a (a) and (d), 70.20b (c) and (e), 70.21(c), 70.24(b), 70.32 (a)(6), (c), (d), (e), and (g), 70.36, 70.51 (c)–(g), 70.56, 70.57 (b) and (d), and 70.58 (a)–(g)(3) and (h)–(j) are issued under sec. 161i, 68 Stat. 949, as amended (42 U.S.C. 2201(i)); and §§ 70.5, 70.9, 70.20b (d) and (e), 70.38, 70.51 (b) and (i), 70.52, 70.53, 70.54, 70.55, 70.58 (g)(4), (k), and (l), 70.59, and 70.60 (b) and (c) are issued under sec. 161o, 68 Stat. 950, as amended (42 U.S.C. 2201(o)).

SOURCE: 21 FR 764, Feb. 3, 1956, unless otherwise noted.

EDITORIAL NOTE: For nomenclature changes to this part, see 40 FR 8791 and 8792, Mar. 3, 1975, and 45 FR 14201, Mar. 5, 1980.

GENERAL PROVISIONS

§ 70.1 Purpose.

(a) Except as provided in paragraph (c) of this section, the regulations of this part, establish procedures and criteria for the issuance of licenses to receive title to, own, acquire, deliver, receive, possess, use, and initially transfer special nuclear material; and establish and provide for the terms and conditions upon which the Commission will issue such licenses.

(b) The regulations contained in this part are issued pursuant to the Atomic Energy Act of 1954, as amended (68 Stat. 919) and Title II of the Energy Reorganization Act of 1974 (88 Stat. 1242).

(c) The regulations in Part 72 of this chapter establish requirements, procedures, and criteria for the issuance of licenses to possess:

(1) Spent fuel and other radioactive materials associated with spent fuel storage in an independent spent fuel storage installation (ISFSI), or

(2) Spent fuel, high-level radioactive waste, and other radioactive materials asociated with the storage in a monitored retrievable storage installation (MRS), and the terms and conditions under which the Commission will issue such licenses.

[21 FR 764, Feb. 3, 1956, as amended at 32 FR 4056, Mar. 15, 1967; 40 FR 8791, Mar. 3, 1975; 43 FR 6924, Feb. 17, 1978; 45 FR 74712, Nov. 12, 1980; 53 FR 31682, Aug. 19, 1988]

§ 70.2 Scope.

Except as provided in §§ 70.11 to 70.13, inclusive, the regulations in this part apply to all persons in the United States.

§ 70.3 License requirements.

No person subject to the regulations in this part shall receive title to, own, acquire, deliver, receive, possess, use, or transfer special nuclear material except as authorized in a license issued by the Commission pursuant to these regulations.

[32 FR 2562, Feb. 7, 1967, as amended at 43 FR 6924, Feb. 17, 1978]

§ 70.4 Definitions.

"Act" means the Atomic Energy Act of 1954 (68 Stat 919), including any amendments thereto;

"Agreement State" as designated in Part 150 of this chapter means any State with which the Commission has entered into an effective agreement under subsection 274b. of the Act. "Non-agreement State" means any other State.

"Alert" means events may occur, are in progress, or have occurred that could lead to a release of radioactive material[s] but that the release is not expected to require a response by an offsite response organization to protect persons offsite.

"Atomic energy" means all forms of energy released in the course of nuclear fission or nuclear transformation;

"Atomic weapon" means any device utilizing atomic energy, exclusive ofthe means for transporting or propelling the device (where such means is a separable and divisible part of the device), the principal purpose of which is for use as, or for development of, a weapon, a weapon prototype, or a weapon test device;

"Commencement of construction" means any clearing of land, excavation, or other substantial action that would adversely affect the natural environment of a site but does not include changes desirable for the temporary use of the land for public recreational uses, necessary borings to determine site characteristics or other preconstruction monitoring to establish background information related to the suitability of a site or to the protection of environmental values.

"Commission" means the Nuclear Regulatory Commission or its duly authorized representatives;

"Common defense and security" means the common defense and security of the United States;

"Decommission" means to remove (as a facility) safely from service and reduce residual radioactivity to a level that permits release of the property for unrestricted use and termination of license.

"Department" and "Department of Energy" means the Department of Energy Organization Act (Pub. L. 95-

91, 91 Stat. 565, 42 U.S.C. 7101 *et seq.*), to the extent that the Department, or its duly authorized representatives, exercises functions formerly vested in the U.S. Atomic Energy Commission, its Chairman, members, officers and components and transferred to the U.S. Energy Research and Development Administration and to the Administrator thereof pursuant to sections 104(b), (c) and (d) of the Energy Reorganization Act of 1974 (Pub. L. 93-438, 88 Stat. 1233 at 1237, 42 U.S.C. 5814) and retransferred to the Secretary of Energy pursuant to section 301(a) of the Department of Energy Organization Act (Pub. L. 95-91, 91 Stat. 565 at 577-578, 42 U.S.C. 7151).

"Effective dose equivalent" means the sum of the products of the dose equivalent to the body organ or tissue and the weighting factors applicable to each of the body organs or tissues that are irradiated. Weighting factors are: 0.25 for gonads, 0.15 for breast, 0.12 for red bone marrow, 0.12 for lungs, 0.03 for thyroid, 0.03 for bone surface, and 0.06 for each of the other five organs receiving the highest dose equivalent.

"Effective kilograms of special nuclear material" means: (1) For plutonium and uranium-233 their weight in kilograms; (2) For uranium with an enrichment in the isotope U-235 of 0.01 (1%) and above, its element weight in kilograms multiplied by the square of its enrichment expressed as a decimal weight fraction; and (3) For uranium with an enrichment in the isotope U-235 below 0.01 (1%), by its element weight in kilograms multiplied by 0.0001.

"Formula quantity" means strategic special nuclear material in any combination in a quantity of 5000 grams or more computed by the formula, grams=(grams contained U^{235}) +2.5 (grams U^{233}+grams plutonium).

"Government agency" means any executive department, commission, independent establishment, corporation, wholly or partly owned by the United States of America which is an instrumentality of the United States, or any board, bureau, division, service, office, officer, authority, administration, or other establishment in the executive branch of the Government;

"License", except where otherwise specified, means a license issued pursuant to the regulations in this part;

"Person" means (1) any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, Government agency other than the Commission or the Department, except that the Department shall be considered a person within the meaning of the regulations in this part to the extent that its facilities and activities are subject to the licensing and related regulatory authority of the Commission pursuant to section 202 of the Energy Reorganization Act of 1974 (88 Stat. 1244),[9] any State or any political subdivision of or any political entity within a State, any foreign government or nation or any political subdivision of any such government or nation, or other entity; and (2) any legal successor, representative, agent, or agency of the foregoing;

"Plutonium processing and fuel fabrication plant" means a plant in which the following operations or activities are conducted: (1) Operations for manufacture of reactor fuel containing plutonium including any of the following: (i) Preparation of fuel material; (ii) formation of fuel material into desired shapes; (iii) application of protec-

[9] The Department facilities identified in section 202 are:

(1) Demonstration Liquid Metal Fast Breeder reactors when operated as part of the power generation facilities of an electric utility system, or when operated in any other manner for the purpose of demonstrating the suitability for commercial application of such a reactor.

(2) Other demonstration nuclear reactors, except those in existence on January 19, 1975, when operated as part of the power generation facilities of an electric utility system, or when operated in any other manner for the purpose of demonstrating the suitability for commercial application of such a reactor.

(3) Facilities used primarily for the receipt and storage of high-level radioactive wastes resulting from licensed activities.

(4) Retrievable Surface Storage Facilities and other facilities authorized for the express purpose of subsequent long-term storage of high-level radioactive waste generated by the Department, which are not used for, or are part of, research and development activities.

tive cladding; (iv) recovery of scrap material; and (v) storage associated with such operations; or (2) research and development activities involving any of the operations described in paragraph (r) (1) of this section, except for research and development activities utilizing unsubstantial amounts of plutonium.

"Produce", when used in relation to special nuclear material, means (1) to manufacture, make, produce, or refine special nuclear material; (2) to separate special nuclear material from other substances in which such material may be contained; or (3) to make or to produce new special nuclear material;

"Research and development" means (1) theoretical analysis, exploration, or experimentation; or (2) the extension of investigative findings and theories of a scientific or technical nature into practical application for experimental and demonstration purposes, including the experimental production and testing of models, devices, equipment, materials, and processes;

"Restricted Data" means all data concerning (1) design, manufacture or utilization of atomic weapons; (2) the production of special nuclear material; or (3) the use of special nuclear material in the production of energy, but shall not include data declassified or removed from the Restricted Data category pursuant to section 142 of the Act;

"Sealed source" means any special nuclear material that is encased in a capsule designed to prevent leakage or escape of the special nuclear material.

"Site Area emergency" means events may occur, are in progress, or have occurred that could lead to a significant release of radioactive material and that could require a response by offsite response organizations to protect persons offsite.

"Source material" means source material as defined in section 11z. of the Act and in the regulations contained in Part 40 of this chapter;

"Special nuclear material" means (1) plutonium, uranium 233, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the Commission, pursuant to the provisions of section 51 of the act, determines to be special nuclear material, but does not include source material; or (2) any material artificially enriched by any of the foregoing but does not include source material;

"Special nuclear material of low strategic significance" means: (1) Less than an amount of special nuclear material of moderate strategic significance, as defined in § 70.4(z)(1), but more than 15 grams of uranium-235 (contained in uranium enriched to 20 percent or more in the U^{235} isotope) or 15 grams of uranium-233 or 15 grams of plutonium or the combination of 15 grams when computed by the equation, grams = (grams contained U^{235}) + (grams plutonium)+(grams U^{233}); or (2) Less than 10,000 grams but more than 1000 grams of uranium-235 (contained in uranium enriched to 10 percent or more but less than 20 percent in the U^{235} isotope); or (3) 10,000 grams or more of uranium-235 (contained in uranium enriched above natural but less than 10 percent in the U^{235} isotope).

"Special nuclear material of moderate strategic significance" means: (1) Less than a formula quantity of strategic special nuclear material but more than 1000 grams of uranium-235 (contained in uranium enriched to 20 percent or more in the U^{235} isotope) or more than 500 grams of uranium-233 or plutonium or in a combined quantity of more than 1000 grams when computed by the equation, grams=(grams contained U^{235})+2 (grams U^{233} + grams plutonium); or (2) 10,000 grams or more of uranium-235 (contained in uranium enriched to 10 percent or more but less than 20 percent in the U^{235} isotope).

"Special nuclear material scrap" means the various forms of special nuclear material generated during chemical and mechanical processing, other than recycle material and normal process intermediates, which are unsuitable for use in their present form, but all or part of which will be used after further processing.

"Strategic special nuclear material" means uranium-235 (contained in uranium enriched to 20 percent or more in the U^{235} isotope), uranium-233, or plutonium.

APPENDIX C

§ 19.20 Employee protection.

Employment discrimination by a licensee or a contractor or subcontractor of a licensee against an employee for engaging in protected activities under this part or Parts 30, 40, 50, 60, 70, 72, or 150 of this chapter is prohibited.

[47 FR 30454, July 14, 1982]

§ 19.30 Violations.

An injunction or other court order may be obtained prohibiting any violation of any provision of the Act or Title II of the Energy Reorganization Act of 1974, or any regulation or order issued thereunder. A court order may be obtained for the payment of a civil penalty imposed pursuant to section 234 of the Act for violation of sections 53, 57, 62, 63, 81, 82, 101, 103, 104, 107, or 109 of the Act or any rule, regulation, or order issued thereunder, or any term, condition or limitation of any licensee issued thereunder, or for any violation for which a license may be revoked under section 186 of the Act. Any person who willfully violates any provision of the Act or any regulation or order issued thereunder may be guilty of a crime and, upon conviction, may be punished by fine or imprisonment or both, as provided by law.

[38 FR 22217, Aug. 17, 1973, as amended at 40 FR 8783, Mar. 3, 1975]

§ 19.31 Application for exemptions.

The Commission may upon application by any licensee or upon its own initiative, grant such exemptions from the requirements of the regulations in this part as it determines are authorized by law and will not result in undue hazard to life or property.

§ 19.32 Discrimination prohibited.

No person shall on the ground of sex be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity licensed by the Nuclear Regulatory Commission. This provision will[1] be enforced through agency provisions and rules similar to those already established, with respect to racial and other discrimination, under Title VI of the Civil Rights Act of 1964. This remedy is not exclusive, however, and will not prejudice or cut off any other legal remedies available to a discriminatee.

[40 FR 8783, Mar. 3, 1975]

PART 20—STANDARDS FOR PROTECTION AGAINST RADIATION

General Provisions

Sec.

Permissible Doses, Levels and Concentrations

Precautionary Procedures

Waste Disposal

[25 FR 10914, Nov. 17, 1960, as amended at 26 FR 352, Jan. 18, 1961; 36 FR 23138, Dec. 4, 1971; 47 FR 57479, Dec. 27, 1982]

§ 20.303 Disposal by release into sanitary sewerage systems.

No licensee shall discharge licensed material into a sanitary sewerage system unless:

(a) It is readily soluble or dispersible in water; and

(b) The quantity of any licensed or other radioactive material released into the system by the licensee in any one day does not exceed the larger of paragraphs (b)(1) or (2) of this section.

(1) The quantity which, if diluted by the average daily quantity of sewage released into the sewer by the licensee, will result in an average concentration equal to the limits specified in Appendix B, Table I, Column 2 of this part; or

(2) Ten times the quantity of such material specified in Appendix C of this part; and

(c) The quantity of any licensed or other radioactive material released in any one month, if diluted by the average monthly quantity of water released by the licensee, will not result in an average concentration exceeding the limits specified in Appendix B, Table I, Column 2 of this part; and

(d) The gross quantity of licensed and other radioactive material, excluding hydrogen-3 and carbon-14, released into the sewerage system by the licensee does not exceed one curie per year. The quantities of hydrogen-3 and carbon-14 released into the sanitary sewerage system may not exceed 5 curies per year for hydrogen-3 and 1 curie per year for carbon-14. Excreta from individuals undergoing medical diagnosis or therapy with radioactive material shall be exempt from any limitations contained in this section.

[25 FR 10914, Nov. 17, 1960, as amended at 46 FR 16234, Mar. 11, 1981]

§ 20.305 Treatment or disposal by incineration.

No licensee shall treat or dispose of licensed material by incineration except for materials listed under § 20.306 or as specifically approved by the Commission pursuant to §§ 20.106(b) and 20.302.

[46 FR 16234, Mar. 11, 1981]

§ 20.306 Disposal of specific wastes.

Any licensee may dispose of the following licensed material without regard to its radioactivity:

(a) 0.05 microcuries or less of hydrogen-3 or carbon-14, per gram of medium, used for liquid scintillation counting; and

(b) 0.05 microcuries or less of hydrogen-3 or carbon-14, per gram of animal tissue averaged over the weight of the entire animal; provided however, tissue may not be disposed of under this section in a manner that would permit its use either as food for humans or as animal feed.

(c) Nothing in this section, however, relieves the licensee of maintaining records showing the receipt, transfer and disposal of such byproduct material as specified in § 30.51 of this chapter; and

(d) Nothing in this section relieves the licensee from complying with other applicable Federal, State and local regulations governing any other toxic or hazardous property of these materials.

[46 FR 16234, Mar. 11, 1981]

§ 20.311 Transfer for disposal and manifests.

(a) *Purpose.* The requirements of this section are designed to control transfers of radioactive waste intended for disposal at a land disposal facility and establish a manifest tracking system and supplement existing requirements concerning transfers and recordkeeping for such wastes. The reporting and recordkeeping requirements contained in this section have been approved by the Office of Management and Budget; OMB approval No. 3150-0014.

(b) Each shipment of radioactive waste to a licensed land disposal facility must be accompanied by a shipment manifest that contains the name, address, and telephone number of the person generating the waste. The manifest shall also include the name, address, and telephone number or the name and EPA hazardous waste identification number of the person transporting the waste to the land disposal

APPENDIX B—CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—Continued

[See footnotes at end of Appendix B]

Element (atomic number)	Isotope		Table I		Table II	
			Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)	Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)
Lutetium (71)	Lu 177	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Manganese (25)	Mn 52	S	2×10^{-7}	1×10^{-3}	7×10^{-9}	3×10^{-5}
		I	1×10^{-7}	9×10^{-4}	5×10^{-9}	3×10^{-5}
	Mn 54	S	4×10^{-7}	4×10^{-3}	1×10^{-8}	1×10^{-4}
		I	4×10^{-8}	3×10^{-4}	1×10^{-9}	1×10^{-5}
	Mn 56	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Mercury (80)	Hg 197m	S	7×10^{-7}	6×10^{-3}	3×10^{-8}	2×10^{-4}
		I	8×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	Hg 197	S	1×10^{-6}	9×10^{-3}	4×10^{-8}	3×10^{-4}
		I	3×10^{-6}	1×10^{-2}	9×10^{-8}	5×10^{-4}
	Hg 203	S	7×10^{-8}	5×10^{-4}	2×10^{-9}	2×10^{-5}
		I	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
Molybdenum (42)	Mo 99	S	7×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}
Neodymium (60)	Nd 144	S	8×10^{-11}	2×10^{-6}	3×10^{-12}	7×10^{-8}
		I	3×10^{-10}	2×10^{-6}	1×10^{-11}	8×10^{-8}
	Nd 147	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	2×10^{-7}	2×10^{-3}	8×10^{-9}	6×10^{-5}
	Nd 149	S	2×10^{-6}	8×10^{-3}	6×10^{-8}	3×10^{-4}
		I	1×10^{-6}	8×10^{-3}	5×10^{-8}	3×10^{-4}
Neptunium (93)	Np 237	S	4×10^{-12}	9×10^{-7}	1×10^{-13}	3×10^{-8}
		I	1×10^{-10}	9×10^{-6}	4×10^{-12}	3×10^{-7}
	Np 239	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	7×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-4}
Nickel (28)	Ni 59	S	5×10^{-7}	6×10^{-3}	2×10^{-8}	2×10^{-4}
		I	8×10^{-7}	6×10^{-2}	3×10^{-8}	2×10^{-3}
	Ni 63	S	6×10^{-8}	8×10^{-4}	2×10^{-9}	3×10^{-5}
		I	3×10^{-7}	2×10^{-2}	1×10^{-8}	7×10^{-4}
	Ni 65	S	9×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Niobium (Columbium) (41)	Nb 93m	S	1×10^{-7}	1×10^{-3}	4×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-2}	5×10^{-9}	4×10^{-4}
	Nb 95	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	1×10^{-7}	3×10^{-3}	3×10^{-9}	1×10^{-4}
	Nb 97	S	6×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
		I	5×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
Osmium (76)	Os 185	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	5×10^{-6}	2×10^{-2}	2×10^{-9}	7×10^{-5}
	Os 191m	S	2×10^{-5}	7×10^{-2}	6×10^{-7}	3×10^{-3}
		I	9×10^{-6}	7×10^{-2}	3×10^{-7}	2×10^{-3}
	Os 191	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-4}
		I	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
	Os 193	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	3×10^{-7}	2×10^{-3}	9×10^{-9}	5×10^{-5}
Palladium (46)	Pd 103	S	1×10^{-6}	1×10^{-2}	5×10^{-8}	3×10^{-4}
		I	7×10^{-7}	8×10^{-3}	3×10^{-8}	3×10^{-4}
	Pd 109	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
Phosphorus (15)	P 32	S	7×10^{-8}	5×10^{-4}	2×10^{-9}	2×10^{-5}
		I	8×10^{-8}	7×10^{-4}	3×10^{-9}	2×10^{-5}
Platinum (78)	Pt 191	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
	Pt 193m	S	7×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
		I	5×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
	Pt 193	S	1×10^{-6}	3×10^{-2}	4×10^{-8}	9×10^{-4}
		I	3×10^{-7}	5×10^{-2}	1×10^{-8}	2×10^{-3}
	Pt 197m	S	6×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
		I	5×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
	Pt 197	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Plutonium (94)	Pu 238	S	2×10^{-12}	1×10^{-6}	7×10^{-14}	5×10^{-8}
		I	3×10^{-11}	8×10^{-6}	1×10^{-12}	3×10^{-7}
	Pu 239	S	2×10^{-12}	1×10^{-6}	6×10^{-14}	5×10^{-8}

APPENDIX B—CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—Continued

[See footnotes at end of Appendix B]

Element (atomic number)	Isotope [1]		Table I		Table II	
			Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)	Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)
		I	4×10^{-11}	8×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 240	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	5×10^{-6}
		I	4×10^{-11}	8×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 241	S	9×10^{-11}	7×10^{-3}	3×10^{-12}	2×10^{-4}
		I	4×10^{-8}	4×10^{-2}	1×10^{-9}	1×10^{-3}
	Pu 242	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	5×10^{-6}
		I	4×10^{-11}	9×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 243	S	2×10^{-8}	1×10^{-2}	6×10^{-10}	3×10^{-4}
		I	2×10^{-8}	1×10^{-2}	8×10^{-10}	3×10^{-4}
	Pu 244	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	4×10^{-6}
		I	3×10^{-11}	3×10^{-4}	1×10^{-12}	1×10^{-5}
Polonium (84)	Po 210	S	5×10^{-10}	2×10^{-5}	2×10^{-11}	7×10^{-7}
		I	2×10^{-10}	8×10^{-6}	7×10^{-12}	3×10^{-7}
Potassium (19)	K42	S	2×10^{-6}	9×10^{-3}	7×10^{-8}	3×10^{-4}
		I	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
Praseodymium (59)	Pr 142	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	2×10^{-7}	9×10^{-4}	5×10^{-9}	3×10^{-5}
	Pr 143	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	5×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	5×10^{-5}
Promethium (61)	Pm 147	S	6×10^{-8}	6×10^{-3}	2×10^{-9}	2×10^{-4}
		I	1×10^{-7}	6×10^{-3}	3×10^{-9}	2×10^{-4}
	Pm 149	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
Protoactinium (91)	Pa 230	S	2×10^{-9}	7×10^{-5}	6×10^{-11}	2×10^{-6}
		I	8×10^{-10}	7×10^{-5}	3×10^{-11}	2×10^{-6}
	Pa 231	S	1×10^{-12}	3×10^{-5}	4×10^{-14}	9×10^{-7}
		I	1×10^{-10}	8×10^{-6}	4×10^{-12}	2×10^{-6}
	Pa 233	S	6×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-4}
		I	2×10^{-7}	3×10^{-3}	6×10^{-9}	1×10^{-4}
Radium (88)	Ra 223	S	2×10^{-9}	2×10^{-5}	6×10^{-11}	7×10^{-7}
		I	2×10^{-10}	1×10^{-4}	8×10^{-12}	4×10^{-6}
	Ra 224	S	5×10^{-9}	7×10^{-5}	2×10^{-10}	2×10^{-6}
		I	7×10^{-10}	2×10^{-4}	2×10^{-11}	5×10^{-6}
	Ra 226	S	3×10^{-11}	4×10^{-7}	3×10^{-12}	3×10^{-8}
		I	5×10^{-11}	9×10^{-4}	2×10^{-12}	3×10^{-5}
	Ra 228	S	7×10^{-11}	8×10^{-7}	2×10^{-12}	3×10^{-6}
		I	4×10^{-11}	7×10^{-4}	1×10^{-12}	3×10^{-5}
Radon (86)	Rn 220	S	3×10^{-7}		1×10^{-8}	
	Rn 222 [3]		3×10^{-8}		3×10^{-9}	
Rhenium (75)	Re 183	S	3×10^{-8}	2×10^{-3}	9×10^{-9}	6×10^{-4}
		I	2×10^{-7}	8×10^{-3}	5×10^{-9}	3×10^{-4}
	Re 186	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-5}
	Re 187	S	9×10^{-6}	7×10^{-2}	3×10^{-7}	3×10^{-3}
		I	5×10^{-7}	4×10^{-3}	2×10^{-8}	2×10^{-3}
	Re 188	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-5}
Rhodium (45)	Rh 103m	S	8×10^{-5}	4×10^{-1}	3×10^{-6}	1×10^{-2}
		I	6×10^{-5}	3×10^{-1}	2×10^{-6}	1×10^{-2}
	Rh 105	S	6×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Rubidium (37)	Rb 86	S	3×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
		I	7×10^{-9}	7×10^{-4}	2×10^{-9}	2×10^{-5}
	Rb 87	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	7×10^{-9}	5×10^{-5}	2×10^{-9}	2×10^{-6}
Ruthenium (44)	Ru 97	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	6×10^{-8}	3×10^{-4}
	Ru 103	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	8×10^{-8}	2×10^{-3}	3×10^{-9}	8×10^{-5}
	Ru 105	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
	Ru 106	S	8×10^{-6}	4×10^{-2}	3×10^{-7}	1×10^{-3}
		I	6×10^{-8}	3×10^{-4}	2×10^{-10}	1×10^{-5}
Samarium (62)	Sm 147	S	7×10^{-11}	2×10^{-3}	2×10^{-12}	6×10^{-5}
		I	3×10^{-10}	2×10^{-3}	9×10^{-12}	7×10^{-5}

APPENDIX B—CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—Continued

[See footnotes at end of Appendix B]

Element (atomic number)	Isotope [1]		Table I		Table II	
			Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)	Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)
		I	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
Terbium (65)	Tb 160	S	1×10^{-7}	1×10^{-3}	3×10^{-9}	4×10^{-5}
		I	3×10^{-6}	1×10^{-3}	1×10^{-8}	4×10^{-5}
Thallium (81)	Tl 200	S	3×10^{-6}	1×10^{-3}	9×10^{-8}	4×10^{-5}
		I	1×10^{-6}	7×10^{-4}	4×10^{-8}	2×10^{-5}
	Tl 201	S	2×10^{-6}	9×10^{-4}	7×10^{-8}	3×10^{-5}
		I	9×10^{-7}	5×10^{-4}	3×10^{-8}	2×10^{-5}
	Tl 202	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	2×10^{-7}	2×10^{-3}	8×10^{-9}	7×10^{-5}
	Tl 204	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	3×10^{-6}	2×10^{-3}	9×10^{-10}	6×10^{-5}
Thorium (90)	Th 227	S	3×10^{-10}	5×10^{-4}	1×10^{-11}	2×10^{-5}
		I	2×10^{-10}	5×10^{-4}	6×10^{-12}	2×10^{-5}
	Th 228	S	9×10^{-12}	2×10^{-4}	3×10^{-13}	7×10^{-6}
		I	6×10^{-12}	4×10^{-4}	2×10^{-13}	1×10^{-5}
	Th 230	S	2×10^{-12}	5×10^{-5}	8×10^{-14}	2×10^{-6}
		I	1×10^{-11}	9×10^{-4}	3×10^{-13}	3×10^{-5}
	Th 231	S	1×10^{-6}	7×10^{-3}	5×10^{-8}	2×10^{-4}
		I	1×10^{-6}	7×10^{-3}	4×10^{-8}	2×10^{-4}
	Th 232	S	3×10^{-11}	5×10^{-5}	1×10^{-12}	2×10^{-6}
		I	3×10^{-11}	1×10^{-3}	1×10^{-12}	4×10^{-5}
	Th natural	S	6×10^{-11}	6×10^{-5}	2×10^{-12}	2×10^{-6}
		I	6×10^{-11}	6×10^{-4}	2×10^{-12}	2×10^{-5}
	Th 234	S	6×10^{-8}	5×10^{-4}	2×10^{-9}	2×10^{-5}
		I	3×10^{-6}	5×10^{-4}	1×10^{-8}	2×10^{-5}
Thulium (69)	Tm 170	S	4×10^{-8}	1×10^{-3}	1×10^{-9}	5×10^{-5}
		I	3×10^{-8}	1×10^{-3}	1×10^{-9}	5×10^{-5}
	Tm 171	S	1×10^{-7}	1×10^{-3}	4×10^{-9}	5×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-5}
Tin (50)	Sn 113	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	9×10^{-5}
		I	5×10^{-8}	2×10^{-3}	2×10^{-9}	8×10^{-5}
	Sn 125	S	1×10^{-7}	5×10^{-4}	4×10^{-9}	2×10^{-5}
		I	8×10^{-8}	5×10^{-4}	3×10^{-9}	2×10^{-5}
Tungsten (Wolfram) (74)	W 181	S	2×10^{-6}	1×10^{-3}	8×10^{-8}	4×10^{-5}
		I	1×10^{-7}	1×10^{-3}	4×10^{-9}	3×10^{-5}
	W 185	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
	W 187	S	4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
Uranium (92)	U 230	S	3×10^{-10}	1×10^{-4}	1×10^{-11}	5×10^{-6}
		I	1×10^{-10}	1×10^{-4}	4×10^{-12}	5×10^{-6}
	U 232	S	1×10^{-10}	8×10^{-4}	3×10^{-12}	3×10^{-5}
		I	3×10^{-11}	8×10^{-4}	9×10^{-13}	3×10^{-5}
	U 233	S	5×10^{-10}	9×10^{-4}	2×10^{-11}	3×10^{-5}
		I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
	U 234	S [4]	6×10^{-10}	9×10^{-4}	2×10^{-11}	3×10^{-5}
		I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
	U 235	S [4]	5×10^{-10}	8×10^{-4}	2×10^{-11}	3×10^{-5}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	U 236	S	6×10^{-10}	1×10^{-3}	2×10^{-11}	3×10^{-5}
		I	1×10^{-10}	1×10^{-3}	4×10^{-12}	3×10^{-5}
	U 238	S [4]	7×10^{-11}	1×10^{-3}	3×10^{-12}	4×10^{-5}
		I	1×10^{-10}	1×10^{-3}	5×10^{-12}	4×10^{-5}
	U 240	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	3×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	3×10^{-5}
	U-natural	S [4]	1×10^{-10}	1×10^{-3}	5×10^{-12}	3×10^{-5}
		I	1×10^{-10}	1×10^{-3}	5×10^{-12}	3×10^{-5}
Vanadium (23)	V 48	S	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-5}
		I	6×10^{-8}	8×10^{-4}	2×10^{-9}	3×10^{-5}
Xenon (54)	Xe 131m	Sub	2×10^{-5}		4×10^{-7}	
	Xe 133	Sub	1×10^{-5}		3×10^{-7}	
	Xe 133m	Sub	1×10^{-5}		3×10^{-7}	
	Xe 135	Sub	4×10^{-6}		1×10^{-7}	
Ytterbium (70)	Yb 175	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}

APPENDIX D

provided in Condition 2 of the Master Policy until paid;

And it is hereby expressly agreed that copies of written notices of retrospective premiums and allowances for premium taxes due and payable or other evidence of such amounts due and payable sworn to by a duly authorized representative of the companies shall be prima facie evidence of the fact and extent of the liability of the named insureds for such amounts;

And it is further expressly agreed that the named insureds will indemnify the companies against any and all liability, losses and expenses of whatsoever kind or nature (including but not limited to interest, court cost, and counsel fees) which the companies may sustain or incur (1) by reason of the failure of the named insureds to comply with the convenants and provisions of this Bond and (2) in enforcing any of the convenants or provisions of this Bond, or any provisions of the Master Policy relating to such convenants or provisions;

For the purpose of recording this agreement, a photocopy acknowledged before a Notary Public to be a true copy hereof shall be regarded as an original.

The preceding Certificate of Insurance, Declarations and Bond form a part of the Master Policy. Cancellation or termination of the Master Policy or the Certificate of Insurance shall not affect the named insured's obligations under the policy or the Bond to pay the retrospective premiums and allowances for premium taxes, as provided in this *Certificate* and Condition 2 of the Master Policy.

In witness whereof, the named insureds have caused the Declaration and the Bond for Payment of Retrospective Premiums to be signed and sealed by a duly authorized officer, to be effective ———— eastern standard time.

Attest or Witness

Named Insureds:

By ————————————

(Seal)

(Signature of Officer)

————————————

(type or print Name & Title of Officer)

Date: ————————————

In witness whereof, the companies subscribing the Master Policy have caused the Certificate of Insurance and the Declarations to be signed on their behalf by the President of Nuclear Energy Liability Insurance Association to be effective ———— eastern standard time, and countersigned below by a duly authorized representative.

For the Subscribing Companies of Nuclear Energy Liability Insurance Association.

By: President ————————————

Countersigned by ————————————

(Authorized Representative)

[49 FR 11153, Mar. 26, 1984]

PART 150—EXEMPTIONS AND CONTINUED REGULATORY AUTHORITY IN AGREEMENT STATES AND IN OFFSHORE WATERS UNDER SECTION 274

General Provisions

Continued Commission Regulatory Authority in Offshore Waters

Exemptions in Agreement States

Continued Commission Regulatory Authority in Agreement States

Continued Commission Authority in Agreement States

Reciprocity

Enforcement

AUTHORITY: Sec. 161, 68 Stat. 948, as amended, sec. 274, 73 Stat. 688, as amended

(42 U.S.C. 2201, 2021); sec. 201, as amended, 88 Stat. 1242, as amended (42 U.S.C. 5841).

Sections 150.3, 150.15, 150.15a, 150.31, 150.32 also issued under secs. 11e(2), 81, 68 Stat. 923, 935, as amended, secs. 83, 84, 92 Stat. 3033, 3039 (42 U.S.C. 2014e(2), 2111, 2113, 2114). Section 150.14 also issued under sec. 53, 68 Stat. 930, as amended (42 U.S.C. 2073). Section 150.15 also issued under secs. 135, 141, Pub. L. 97-425, 96 Stat. 2232, 2241 (42 U.S.C. 10155, 10161). Section 150.17a also issued under sec. 122, 68 Stat. 939 (42 U.S.C. 2152). Section 150.30 also issued under sec. 234, 83 Stat. 444 (42 U.S.C. 2282).

For the purposes of sec. 223, 68 Stat. 958, as amended (42 U.S.C. 2273); §§ 150.20(b)(2)-(4) and 150.21 are issued under sec. 161b, 68 Stat. 948, as amended (42 U.S.C. 2201(b)); § 150.14 is issued under sec. 161i, 68 Stat. 949, as amended (42 U.S.C. 2201(i)); and §§ 150.16-150.19 and 150.20(b)(1) are issued under sec. 161o, 68 Stat. 950, as amended (42 U.S.C. 2201(o)).

SOURCE: 27 FR 1352, Feb. 14, 1962, unless otherwise noted.

EDITORIAL NOTE: For nomenclature changes to this part, see 40 FR 8794, Mar. 3, 1975, and 45 FR 14201, Mar. 5, 1980.

GENERAL PROVISIONS

§ 150.1 Purpose.

The regulations in this part provide certain exemptions to persons in Agreement States from the licensing requirements contained in Chapters 6, 7, and 8 of the Act and from the regulations of the Commission imposing requirements upon persons who receive, possess, use or transfer byproduct material, source, or special nuclear material in quantities not sufficient to form a critical mass; and to define activities in Agreement States and in offshore waters over which the regulatory authority of the Commission continues. The provisions of the Act, and regulations of the Commission apply to all persons in Agreement States and in offshore waters engaging in activities over which the regulatory authority of the Commission continues.

[46 FR 44151, Sept. 3, 1981]

§ 150.2 Scope.

The regulations in this part apply to all States that have entered into agreements with the Commission or the Atomic Energy Commission pursuant to subsection 274b of the Act.

[27 FR 1352, Feb. 14, 1962, as amended at 40 FR 8794, Mar. 3, 1975]

§ 150.3 Definitions.

As used in this part:

(a) "Act" means the Atomic Energy Act of 1954 (68 Stat. 919) including any amendments thereto;

(b) "Agreement State" means any State with which the Commission or the Atomic Energy Commission has entered into an effective agreement under subsection 274b of the Act. "Nonagreement State" means any other State.

(c) "Byproduct material" means: (1) Any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material; or (2) the tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content, including discrete surface wastes resulting from solution extraction processes. Underground ore bodies depleted by such solution extraction operations do not constitute "byproduct material" within the definition.

(d) "Commission" means the Nuclear Regulatory Commission or its duly authorized representatives;

(e) "Government agency" means any executive department, commission, independent establishment, corporation, wholly or partly owned by the United States of America which is an instrumentality of the United States, or any board, bureau, division, service, office, officer, authority, administration, or other establishment in the executive branch of the Government.

(f) "Offshore waters" means that area of land and water, beyond Agreement States' Submerged Lands Act jurisdiction, on or above the U.S. Outer Continental Shelf.

(g) "Person" means: (1) Any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, agency, and State or any political subdivision of any political entity within a State, and any legal successor, representative, agent, or agency of the foregoing other than Government agencies;

(h) "Production facility" means: (1) Any equipment or device determined by rule of the Commission to be capable of the production of special nuclear material in such quantity as to be of significance to the common defense and security, or in such manner as to affect the health and safety of the public; or (2) any important component part especially designed for such equipment or device as determined by the Commission;

(i) "Source material" means: (1) Uranium, thorium, or any other material which is determined by the Commission pursuant to the provisions of section 61 of the Act to be source material; or (2) ores containing one or more of the foregoing materials, in such concentration as the Commission may by regulation determine from time to time;

(j) "Special nuclear material" means: (1) Plutonium, uranium 233, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the Commission, pursuant to the provisions of section 51 of the Act, determines to be special nuclear material, but does not include source material; or (2) any material artificially enriched by any of the foregoing but does not include source material;

(k) "State" means any State, the District of Columbia, Puerto Rico, and any territory or possession of the United States; and

(l) "Utilization facility" means: (1) Any equipment or device, except an atomic weapon, determined by rule of the Commission to be capable of making use of special nuclear material in such quantity as to be of significance to the common defense and security, or in such manner as to affect the health and safety of the public, or peculiarly adapted for making use of atomic energy in such quantity as to be of significance to the common defense and security, or in such manner as to affect the health and safety of the public; or (2) any important component part especially designed for such equipment or device as determined by the Commission.

[27 FR 1352, Feb. 14, 1962, as amended at 31 FR 15145, Dec. 2, 1966; 40 FR 8794, Mar. 3, 1975; 44 FR 55327, Sept. 26, 1979; 45 FR 18906, Mar. 24, 1980; 46 FR 44152, Sept. 3, 1981]

§ 150.4 Communications.

Except where otherwise specified in this part, all communications and reports concerning the regulations in this part should be addressed to the Executive Director for Operations, U.S. Nuclear Regulatory Commission, Washington, DC 20555. Communications and reports may be delivered in person at the Commission's offices at 2120 L Street NW, Washington, DC, or at 11555 Rockville Pike, Rockville, Maryland.

[53 FR 6140, Mar. 1, 1988, as amended at 53 FR 43422, Oct. 27, 1988]

§ 150.5 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by an officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding upon the Commission.

Continued Commission Regulatory Authority in Offshore Waters

§ 150.7 Persons in offshore waters not exempt.

Persons in offshore waters are not exempt from the Commission's licensing and regulatory requirements with respect to byproduct, source, and special nuclear materials.

[46 FR 44152, Sept. 3, 1981]

§ 150.8 Information collection requirements: OMB approval.

(a) The Nuclear Regulatory Commission has submitted the information collection requirements contained in this part to the Office of Management and Budget (OMB) for approval as required by the Paperwork Reduction Act of 1980 (44 U.S.C. 3501 et seq.). OMB has approved the information collection requirements contained in this part under control number 3150-0032.

(b) The approved information collection requirements contained in this part appear in §§150.16, 150.17, 150.17a, 150.19, 150.20, and 150.31.

(c) This part contains information collection requirements in addition to those approved under the control number specified in paragraph (a) of this section. These information collection requirements and the control numbers under which they are approved are as follows:

(1) In §§ 150.16 and 150.17, Form NRC-741 is approved under control number 3150-0003.

(2) In § 150.20, Form NRC-241 is approved under control number 3150-0013.

[49 FR 19629, May 9, 1984]

Exemptions in Agreement States

§ 150.10 Persons exempt.

Except as provided in §§ 150.15, 150.16, 150.17, 150.17a, 150.18, and 150.19, any person in an Agreement State who manufactures, produces, receives, possesses, uses, or transfers byproduct material, source material, or special nuclear material in quantities not sufficient to form a critical mass is exempt from the requirements for a license contained in Chapters 6, 7, and 8 of the Act, regulations of the Commission imposing licensing requirements upon persons who manufacture, produce, receive, possess, use, or transfer such materials, and from regulations of the Commission applicable to licensees. The exemptions in this section do not apply to agencies of the Federal government as defined in § 150.3.

[37 FR 9208, May 6, 1972, as amended at 45 FR 50718, July 31, 1980]

§ 150.11 Critical mass.

(a) For the purposes of this part, special nuclear material in quantities not sufficient to form a critical mass means uranium enriched in the isotope U-235 in quantities not exceeding 350 grams of contained U-235; uranium-233 in quantities not exceeding 200 grams; plutonium in quantities not exceeding 200 grams; or any combination of them in accordance with the following formula: For each kind of special nuclear material, determine the ratio between the quantity of that special nuclear material and the quantity specified above for the same kind of special nuclear material. The sum of such ratios for all kinds of special nuclear materials in combination shall not exceed unity. For example, the following quantities in combination would not exceed the limitation and are within the formula, as follows:

(175 (grams contained U-235/350)+(50 grams U-233)/200)+(50 grams Pu/200)=1

(b) To determine whether the exemption granted in § 150.10 applies to the receipt, possession or use of special nuclear material at any particular plant or other authorized location of use, a person shall include in the quantity computed according to paragraph (a) of this section the total quantity of special nuclear material which he is authorized to receive, possess or use at the plant or other location of use at any one time.

[27 FR 1352, Feb. 14, 1962, as amended at 30 FR 12069, Sept. 22, 1965]

Continued Commission Regulatory Authority in Agreement States

§ 150.14 Commission regulatory authority for physical protection.

Persons in Agreement States possessing, using or transporting special nuclear material of low strategic significance in quantities greater than 15 grams of plutonium or uranium-233 or uranium-235 (enriched to 20 percent or more in the U-235 isotope) or any combination greater than 15 grams when computed by the equation grams=grams uranium-235+grams plutonium+grams uranium-233 shall meet the physical protection requirements of § 73.67 of 10 CFR Part 73.

[44 FR 43285, July 24, 1979, as amended at 44 FR 68199, Nov. 28, 1979]

§ 150.15 Persons not exempt.

(a) Persons in agreement States are not exempt from the Commission's licensing and regulatory requirements with respect to the following activities:

(1) The construction and operation of any production or utilization facility. As used in this subparagraph, "operation" of a facility includes, but is not limited to (i) the storage and handling of radioactive wastes at the facil-

APPENDIX E

RULES
OF
THE TENNESSEE DEPARTMENT OF HEALTH AND ENVIRONMENT
BUREAU OF ENVIRONMENT
DIVISION OF RADIOLOGICAL HEALTH

CHAPTER 1200—2—5
STANDARDS FOR PROTECTION AGAINST RADIATION

TABLE OF CONTENTS

1200—2—5—.01 PURPOSE.

(1) This Chapter establishes standards and requirements for protection against radiation hazards. The provisions of this Chapter are in addition to and not in substitution for other applicable provisions of these regulations.

(2) In addition to complying with the standards and requirements of these regulations, all persons shall make every reasonable effort to maintain radiation exposures and releases of radioactive material in effluents to unrestricted areas as low as reasonably achievable. The term "as low as reasonably achievable" means as low as is reasonably achievable taking into account the state of technology and the economics of improvements in relation to benefits to the public health and safety.

Authority: T.C.A. §68—28—101 et seq. Administrative History: Original rule certified June 7, 1974. Amendment filed August 15, 1978; effective October 2, 1978. Amendment filed April 3, 1986; effective May 31, 1986.

1200—2—5—.02 SCOPE. Except as otherwise specifically provided, this chapter applies to all persons who receive, possess, use or transfer sources of radiation.

Authority: T.C.A. §68—28—101 et seq. Administrative History: Original rule certified June 7, 1974. Amendment filed August 15, 1978; effective October 2, 1978. Amendment filed April 3, 1986; effective May 31, 1986.

1200—2—5—.03 EXPOSURE OF INDIVIDUALS TO RADIATION IN RESTRICTED AREAS.

(1) Except as provided in (2) of this rule, no licensee or registrant shall possess, use, receive or transfer sources of radiation in such a manner as to cause any individual in a restricted area to receive in any period of one calendar quarter from all sources of radiation a total occupational dose of radiation in excess of the limits specified in the following table:

ule 1200—2—5—.17, continued)

(i) Any shipment or part of a shipment for which acknowledgement is not received within the times set forth in this paragraph must:

1. Be investigated by the shipper if the shipper has not received notification of receipt within 20 days after transfer; and

2. Be traced and reported. The investigation shall include tracing the shipment and filing a report with the Department. Each licensee who conducts a trace investigation shall file a written report with the Department within 2 weeks of completion of the investigation.

Authority: T.C.A. §§68—23—206 and 68—28—101 et seq. Administrative History: Original rule certified June 7, 1974. Amendment filed August 15, 1978; effective October 2, 1978. Amendment filed April 3, 1986; effective May 31, 1986. Amendment filed July 11, 1988; effective August 25, 1988.

1200—2—5—.18 DISPOSAL BY RELEASE INTO SANITARY SEWERAGE SYSTEMS.

(1) No licensee shall discharge radioactive material into a sanitary sewerage system unless:

(a) It is in solution or dispersed in water; and

(b) The quantity of any radioactive material released into the system by the licensee in any one day does not exceed the larger of subparagraphs (a) and (b) of this paragraph.

1. The quantity, which if diluted by the average daily quantity of sewage released into the sewer by the licensee, will result in an average concentration not greater than the limits specified in Schedule RHS 8—1, Table I, Column 2; or,

2. Ten times the quantity of such material specified in Schedule RHS 8—2; and,

(c) The quantity of any radioactive material released in any 1 month, if diluted by the average monthly quantity of water released by the licensee will not result in an average concentration exceeding the limits specified in Schedule RHS 8—1, Table I, Column 2; and

(d) The gross quantity of radioactive material, excluding hydrogen-3 and carbon-14, released into the sewerage system by the licensee does not exceed one (1) curie per year. The quantities of hydrogen-3 and carbon-14 released into the sanitary sewerage system shall not exceed five (5) curies per year, respectively.

(2) Excreta from individuals undergoing medical diagnosis or therapy with radioactive material shall be exempt from any limitations contained in this rule.

Authority: T.C.A. §68—28—101 et seq. Administrative History: Original rule certified June 7, 1974. Amendment filed August 15, 1978; effective October 2, 1978. Amendment filed April 3, 1986; effective May 31, 1986.

SCHEDULE RHS 8—1 (Cont'd)

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND

(See Notes at End of Schedule)

Element (atomic number)	Isotope[1]		Table I Column 1 Air (uCi/ml)	Table I Column 2 Water (uCi/ml)	Table II Column 1 Air (uCi/ml)	Table II Column 2 Water (uCi/ml)
	Nb-95	S	$5x10^{-7}$	$3x10^{-3}$	$2x10^{-8}$	$1x10^{-4}$
		I	$1x10^{-7}$	$3x10^{-3}$	$3x10^{-9}$	$1x10^{-4}$
	Nb-97	S	$6x10^{-6}$	$3x10^{-2}$	$2x10^{-7}$	$9x10^{-4}$
		I	$5x10^{-6}$	$3x10^{-2}$	$2x10^{-7}$	$9x10^{-4}$
Osmium (76)	Os-185	S	$5x10^{-7}$	$2x10^{-3}$	$2x10^{-8}$	$7x10^{-5}$
		I	$5x10^{-8}$	$2x10^{-3}$	$2x10^{-9}$	$7x10^{-5}$
	Os-191m	S	$2x10^{-5}$	$7x10^{-2}$	$3x10^{-7}$	$3x10^{-3}$
		I	$9x10^{-6}$	$7x10^{-2}$	$3x10^{-7}$	$2x10^{-3}$
	Os-191	S	$1x10^{-6}$	$5x10^{-3}$	$4x10^{-8}$	$2x10^{-4}$
		I	$4x10^{-7}$	$5x10^{-3}$	$1x10^{-8}$	$2x10^{-4}$
	Os-193	S	$4x10^{-7}$	$2x10^{-3}$	$1x10^{-8}$	$6x10^{-5}$
		I	$3x10^{-7}$	$2x10^{-3}$	$9x10^{-9}$	$5x10^{-5}$
Palladium (46)	Pd-103	S	$1x10^{-6}$	$1x10^{-2}$	$5x10^{-8}$	$3x10^{-4}$
		I	$7x10^{-7}$	$8x10^{-3}$	$3x10^{-8}$	$3x10^{-4}$
	Pd-109	S	$6x10^{-7}$	$3x10^{-3}$	$2x10^{-8}$	$9x10^{-5}$
		I	$4x10^{-7}$	$2x10^{-3}$	$1x10^{-8}$	$7x10^{-5}$
Phosphorus (15	P-32	S	$7x10^{-8}$	$5x10^{-4}$	$2x10^{-9}$	$2x10^{-5}$
		I	$8x10^{-8}$	$7x10^{-4}$	$3x10^{-9}$	$2x10^{-5}$
Platinum (78)	Pt-191	S	$8x10^{-7}$	$4x10^{-3}$	$3x10^{-8}$	$1x10^{-4}$
		I	$6x10^{-7}$	$3x10^{-3}$	$2x10^{-8}$	$1x10^{-4}$
	Pt-193m	S	$7x10^{-6}$	$3x10^{-2}$	$2x10^{-7}$	$1x10^{-3}$
		I	$5x10^{-6}$	$3x10^{-2}$	$2x10^{-7}$	$1x10^{-3}$
	Pt-193	S	$1x10^{-6}$	$3x10^{-2}$	$4x10^{-8}$	$9x10^{-4}$
		I	$3x10^{-7}$	$5x10^{-2}$	$1x10^{-8}$	$2x10^{-3}$
	Pt-197m	S	$6x10^{-6}$	$3x10^{-2}$	$2x10^{-7}$	$1x10^{-3}$
		I	$5x10^{-6}$	$3x10^{-2}$	$2x10^{-7}$	$9x10^{-4}$
	Pt-197	S	$8x10^{-7}$	$4x10^{-3}$	$3x10^{-8}$	$1x10^{-4}$
		I	$6x10^{-7}$	$3x10^{-3}$	$2x10^{-8}$	$1x10^{-4}$
Plutonium (94)	Pu-238	S	$2x10^{-12}$	$1x10^{-4}$	$7x10^{-14}$	$5x10^{-6}$
		I	$3x10^{-11}$	$8x10^{-4}$	$1x10^{-12}$	$3x10^{-5}$
	Pu-239	S	$2x10^{-12}$	$1x10^{-4}$	$6x10^{-14}$	$5x10^{-6}$
		I	$4x10^{-11}$	$8x10^{-4}$	$1x10^{-12}$	$3x10^{-5}$
	Pu-240	S	$2x10^{-12}$	$1x10^{-4}$	$6x10^{-14}$	$5x10^{-6}$
		I	$4x10^{-11}$	$8x10^{-4}$	$1x10^{-12}$	$3x10^{-5}$

[1] Soluble (S); Insoluble (I).

[2] "Sub" means that values given are for submersion in a semispherical infinite cloud of airborne material.

[3] These radon concentrations are appropriate for protection from radon-222 combined with its short-lived daughters. Alternatively, the value in Table I may be replaced by one-third (1/3) "working level". (A "working level" is defined as any combination of short-lived radon-222 daughters, polonium-218, lead-214, bismuth-214 and polonium-214, in one liter of air, without regard to the degree of equilibrium, that will result in the ultimate emission of 1.3×10^5 MeV of alpha particle energy.) The Table II value may be replaced by one-thirtieth (1/30) of a "working level". The limit of radon-222 concentrations in restricted areas may be based on an annual average.

[4] For soluble mixtures of U-238, and U-234 and U-235 in air chemical toxicity may be the limiting factor. If the percent by weight (enrichment) of U-235 is less than 5, the concentration value for a 40-hour workweek, Table I, is 0.2 milligrams uranium per cubic meter of air average. For any enrichment, the product of the average concentration and time of exposure during a 40-hour workweek shall not exceed 8×10^{-1} SA uCi-hr/ml, where SA is the specific activity of the uranium inhaled. The concentration value for Table II is 0.007 milligrams uranium per cubic meter of air. The specific activity for natural uranium is 6.77×10^{-7} curies per gram U. The specific activity for other mixtures of U-238, U-235, and U-234, if not known, shall be:

$SA = 3.6 \times 10^{-7}$ curies/gram U — U-depleted

$SA = (0.4 + 0.38\ E + 0.0034\ E^2)\ 10^{-6}$ — $E \geq 0.72$

where E is the percentage by weight of U-235, expressed as percent.

SCHEDULE RHS 8—1 (Cont'd)

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND

(See Notes at End of Schedule)

Element (atomic number)	Isotope[1]		Table I Column 1 Air (uCi/ml)	Table I Column 2 Water (uCi/ml)	Table II Column 1 Air (uCi/ml)	Table II Column 2 Water (uCi/ml)
	U-233	S	$5x10^{-10}$	$9x10^{-4}$	$2x10^{-11}$	$3x10^{-5}$
		I	$1x10^{-10}$	$9x10^{-4}$	$4x10^{-12}$	$3x10^{-5}$
	U-234	S[4]	$6x10^{-10}$	$9x10^{-4}$	$2x10^{-11}$	$3x10^{-5}$
		I	$1x10^{-10}$	$9x10^{-4}$	$4x10^{-12}$	$3x10^{-5}$
	U-235	S[4]	$5x10^{-10}$	$8x10^{-4}$	$2x10^{-11}$	$3x10^{-5}$
		I	$1x10^{-10}$	$8x10^{-4}$	$4x10^{-12}$	$3x10^{-5}$
	U-236	S	$6x10^{-10}$	$1x10^{-3}$	$2x10^{-11}$	$3x10^{-5}$
		I	$1x10^{-10}$	$1x10^{-3}$	$4x10^{-12}$	$3x10^{-5}$
	U-238	S[4]	$7x10^{-11}$	$1x10^{-3}$	$3x10^{-12}$	$4x10^{-5}$
		I	$1x10^{-10}$	$1x10^{-3}$	$5x10^{-12}$	$4x10^{-5}$
	U-240	S	$2x10^{-7}$	$1x10^{-3}$	$8x10^{-9}$	$3x10^{-5}$
		I	$2x10^{-7}$	$1x10^{-3}$	$6x10^{-9}$	$3x10^{-5}$
	U-natural	S[4]	$1x10^{-10}$	$1x10^{-3}$	$5x10^{-12}$	$3x10^{-5}$
		I	$1x10^{-10}$	$1x10^{-3}$	$5x10^{-12}$	$3x10^{-5}$
Vanadium (23)	V-48	S	$2x10^{-7}$	$9x10^{-4}$	$6x10^{-9}$	$3x10^{-5}$
		I	$6x10^{-8}$	$8x10^{-4}$	$2x10^{-9}$	$3x10^{-5}$
Xenon (54)	Xe-131m	Sub[2]	$2x10^{-5}$	——	$4x10^{-7}$	——
	Xe-133m	Sub[2]	$1x10^{-5}$	——	$3x10^{-7}$	——
	Xe-133	Sub[2]	$1x10^{-5}$	——	$3x10^{-7}$	——
	Xe-135	Sub[2]	$4x10^{-6}$	——	$1x10^{-7}$	——
Ytterbium (70)	Yb-175	S	$7x10^{-7}$	$3x10^{-3}$	$2x10^{-8}$	$1x10^{-4}$
		I	$6x10^{-7}$	$3x10^{-3}$	$2x10^{-8}$	$1x10^{-4}$
Yttrium (39)	Y-88	S	$3x10^{-7}$	$2x10^{-3}$	$6x10^{-9}$	$7x10^{-5}$
		I	$5x10^{-8}$	$3x10^{-3}$	$2x10^{-9}$	$9x10^{-5}$
	Y-90	S	$1x10^{-7}$	$6x10^{-4}$	$4x10^{-9}$	$2x10^{-5}$
		I	$1x10^{-7}$	$6x10^{-4}$	$3x10^{-9}$	$2x10^{-5}$
	Y-91m	S	$2x10^{-5}$	$1x10^{-1}$	$8x10^{-7}$	$3x10^{-3}$
		I	$2x10^{-5}$	$1x10^{-1}$	$6x10^{-7}$	$3x10^{-3}$
	Y-91	S	$4x10^{-8}$	$8x10^{-4}$	$1x10^{-9}$	$3x10^{-5}$
		I	$3x10^{-8}$	$8x10^{-4}$	$1x10^{-9}$	$3x10^{-5}$
	Y-92	S	$4x10^{-7}$	$2x10^{-3}$	$1x10^{-8}$	$6x10^{-5}$
		I	$3x10^{-7}$	$2x10^{-3}$	$1x10^{-8}$	$6x10^{-5}$
	Y-93	S	$2x10^{-7}$	$8x10^{-4}$	$6x10^{-9}$	$3x10^{-5}$
		I	$1x10^{-7}$	$8x10^{-4}$	$5x10^{-9}$	$3x10^{-5}$

[1]Soluble (S); Insoluble (I).

[2]"Sub" means that values given are for submersion in a semi-infinite cloud of airborne material.

[3]These radon concentrations are appropriate for protection from radon-222 combined with its short-lived daughters. Alternatively, the value in Table I may be replaced by one-third (1/3) "working level". (A "working level" is defined as any combination of short-lived radon-222 daughters, polonium-218, lead-214, bismuth-214 and polonium-214, in one liter of air, without regard to the degree of equilibrium, that will result in the ultimate emission of 1.3×10^5 MeV of alpha particle energy.) The Table II value may be replaced by one-thirtieth (1/30) of a "working level". The limit of radon-222 concentrations in restricted areas may be based on an annual average.

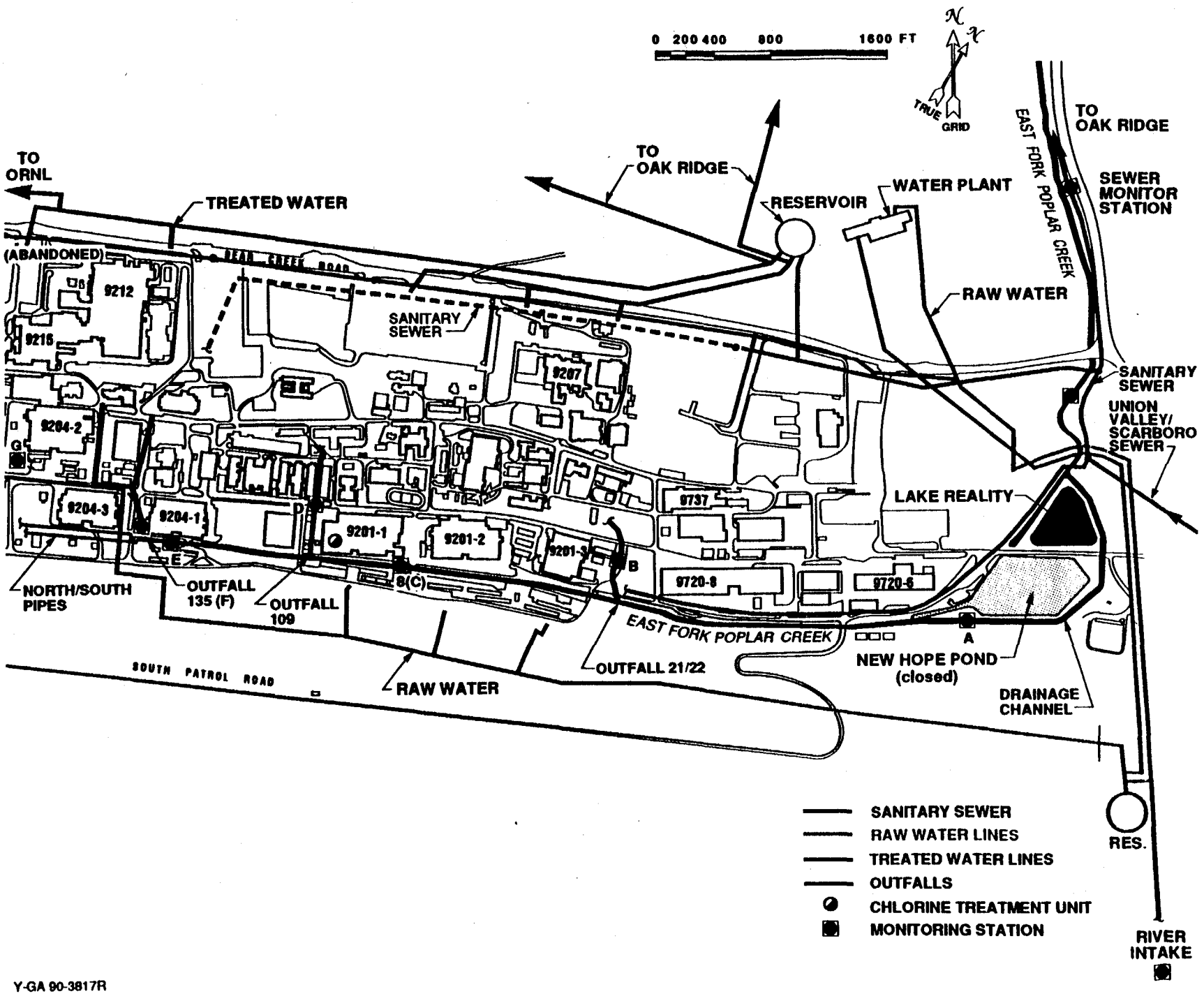
[4]For soluble mixtures of U-238, and U-234 and U-235 in air chemical toxicity may be the limiting factor. If the percent by weight (enrichment) of U-235 is less than 5, the concentration value for a 40-hour work-week, Table I, is 0.2 milligrams uranium per cubic meter of air average. For any enrichment, the product of the average concentration and time of exposure during a 40-hour work-week shall not exceed 8×10^{-4} SA uCi-hr/ml, where SA is the specific activity of the uranium inhaled. The concentration value for Table II is 0.007 milligrams uranium per cubic meter of air. The specific activity for natural uranium is 6.77×10^{-7} curies per gram U. The specific activity for other mixtures of U-238, U-235, and U-234, if not known, shall be:

$SA = 3.6 \times 10^{-7}$ curies/gram U — U-depleted

$SA = (0.4 + 0.38\,E + 0.0034\,E^2)\,10^{-6}$ — $E \geq 6.77$

where E is the percentage by weight of U-235, expressed as percent.

APPENDIX F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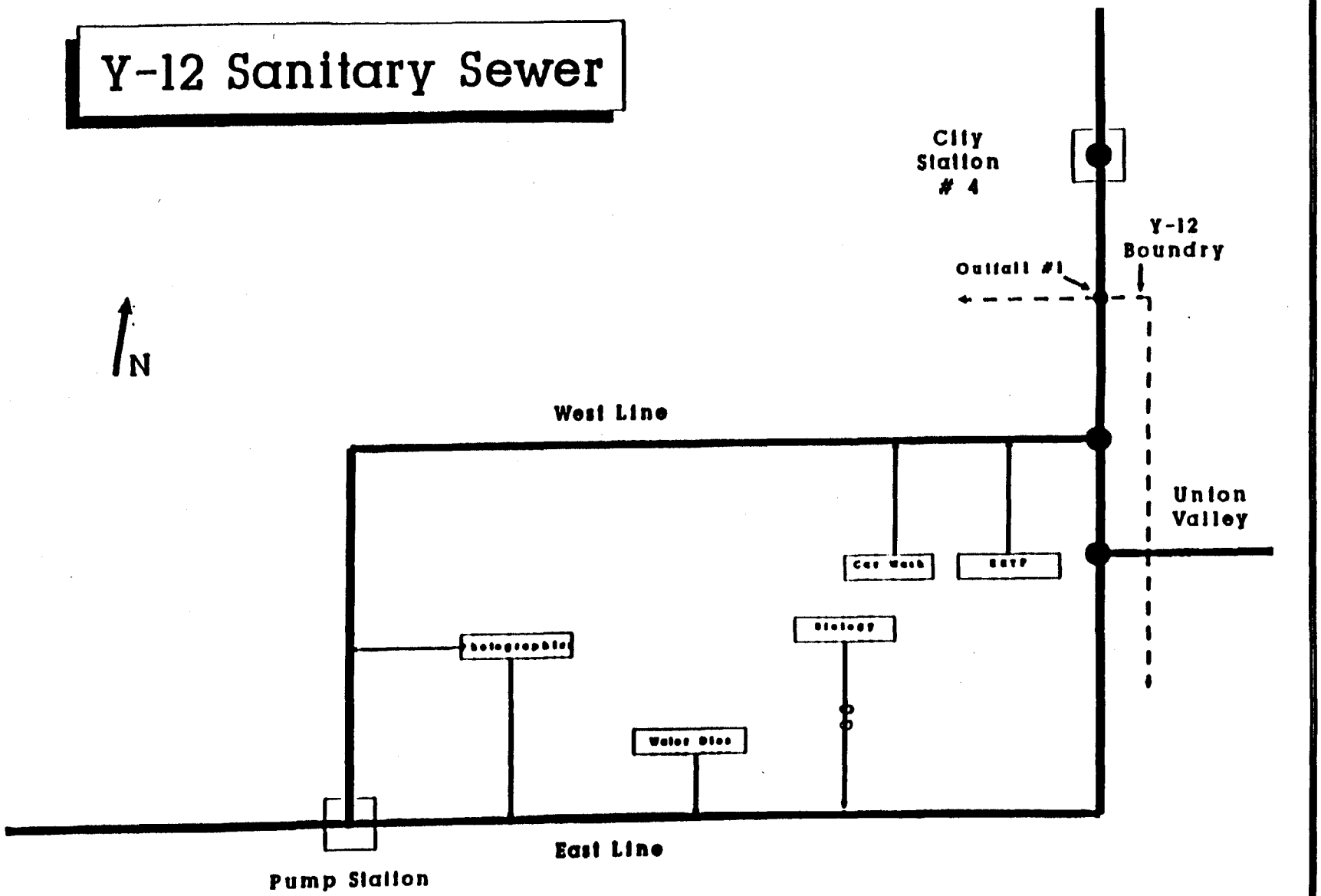
TRUE GRID
TO ORNL
TREATED WATER
(ABANDONED)
BEAR CREEK ROAD
9212
9215
9204-2
9204-3
9204-1
SANITARY SEWER
9207
TO OAK RIDGE
TO OAK RIDGE
RESERVOIR
WATER PLANT
EAST FORK POPLAR CREEK
SEWER MONITOR STATION
RAW WATER
SANITARY SEWER
UNION VALLEY/ SCARBORO SEWER
LAKE REALITY
9737
9201-1
9201-2
9201-3
9720-8
9720-6
NORTH/SOUTH PIPES
OUTFALL 135 (F)
OUTFALL 109
B(C)
EAST FORK POPLAR CREEK
NEW HOPE POND (closed)
DRAINAGE CHANNEL
SOUTH PATROL ROAD
RAW WATER
OUTFALL 21/22
SANITARY SEWER
RAW WATER LINES
TREATED WATER LINES
OUTFALLS
CHLORINE TREATMENT UNIT
MONITORING STATION
RES.
RIVER INTAKE

Y-GA 90-3817R

Y-12 Sanitary Sewer



APPENDIX G

CITY FLOW MONITORING STATION

Station							
	U	%U235	Flow	U	U	U-235	U-235
		%	mgd	G/DAY	LBS/DAY	G/DAY	LBS/DAY
11/15/88	0.015	0.860	0.721	41	0.084	0.35	0.0007
02/24/89	0.004	0.520	0.808	12	0.025	0.06	0.0001
03/07/89	0.033	0.700	0.98	122	0.253	0.86	0.0018
04/05/89	0.127	0.260	1.287	618	1.277	1.61	0.0033
05/03/89	0.014	0.660	1.0035	53	0.110	0.35	0.0007
06/08/89	0.021	0.490	1.0605	84	0.174	0.41	0.0009
07/07/89	0.077	0.250	1.617	471	0.972	1.18	0.0024
08/03/89	0.015	0.480	1.134	64	0.133	0.31	0.0006
09/06/89	0.040	0.290	0.8265	125	0.258	0.36	0.0007
10/06/89	0.008	0.630	0.9165	28	0.057	0.17	0.0004
11/08/89	0.007	0.680	1.04175	28	0.057	0.19	0.0004
12/06/89	0.012	0.578	1.206	55	0.113	0.32	0.0007
1/4/90	0.022	0.320	1.7472	145	0.300	0.46	0.0010
2/2/90	0.005	2.400	1.2885	24	0.050	0.58	0.0012
3/6/90	0.004	2.200	0.6765	10	0.021	0.23	0.0005
4/6/90	0.002	1.000	0.87825	7	0.014	0.07	0.0001
5/3/90	0.006	0.710	1.34625	31	0.063	0.22	0.0004
6/5/90	0.004	0.640	1.04925	16	0.033	0.10	0.0002
7/12/90	0.005	0.940	0.948	18	0.037	0.17	0.0003
8/2/90	0.005	0.86	1.20075	23	0.047	0.20	0.0004
9/6/90	0.003	0.9	2.727	31	0.064	0.28	0.0006
10/10/90	0.009	0.61	2.64225	90	0.186	0.55	0.0011
11/7/90	0.004	2.27	2.631	40	0.082	0.90	0.0019
12/6/90	0.005	0.94	2.7675	52	0.108	0.49	0.0010
1/4/91	0.006	0.8	2.48175	56	0.116	0.45	0.0009
2/6/91	0.003	2.28	2.598	29	0.061	0.67	0.0014
3/6/91	0.007	1.28	1.37775	36	0.075	0.47	0.0010

APPENDIX H

ENDS001 Y-12 PLANT LAB ENVIRONMENTAL ANALYSES REPORT

Requisition: A35826 Env Sample Code: 8601 Sample desc: H2O 24 HR.

Sample loc: SAN.SEW.4
Date: 07-13-91
Time: 08:40

Requester name: HANZELKA ,H
Addr: 9115 ,8219,012
Phone: 4-1599

Sampled by: 30786/22559
Ref Id:

Date received: 07-15-91
Reported: 07-31-91

Handling: NEED 7/23/91

Charge code: S2211001

Remarks:

Approved by: SLAGLE /DHB

****

DC	CAS NUMBER	DETERMINATION	BASIS/PREP	/PHASE	ANSWER		UNITS	DATE	TIME	METHOD	ANA
102	12587-46-1	Alpha Activity	As Rec/Total	/Complete	5.8	+/-0.9	pci/l	07/23/91	13:00	********	033
404		Ammonia, As Nitrogen	As Rec/Total	/Complete	13	+/-1	mg/l	07/19/91	16:30	350.2	116
105	12587-47-2	Beta Activity	As Rec/Total	/Complete	13	+/-2	pci/l	07/23/91	13:00	********	033
'07		Biochemical Oxygen Demand (BO	As Rec/Total	/Complete	36.8	+/-4	mg/l	07/19/91	12:00	405.1	139
1		Chemical Oxygen Demand (COD)	As Rec/Total	/Complete	107	+/-20	mg/l	07/16/91	13:00	410.2	139
414	18540-29-9	Chromium, Hexavalent (Cr+6)	As Rec/Total	/Complete	0.01		mg/l	07/13/91	12:43	218.4	134
024	7439-97-6	Mercury	As Rec/Total	/Complete	0.0019		mg/l	07/19/91	14:02	245.1	095
441		Nitrogen, Kjeldahl	As Rec/Total	/Complete	17	+/-2	mg/l	07/18/91	13:30	351.3	145
121	13981-16-3	Plutonium-238	As Rec/Total	/Complete	0.15	+/-.14	pci/l	07/23/91	13:00	********	102
122		Plutonium-239/240	As Rec/Total	/Complete	-.02	+/-.03	pci/l	07/23/91	13:00	********	102
455		Residue, Non-Filterable (TSS)	As Rec/Total	/Complete	62	+/-6	mg/l	07/16/91	08:30	160.2	044
036	7782-49-2	Selenium	As Rec/Total	/Complete	<0.002		mg/l	07/17/91	13:00	270.2	058
129		Technetium-99	As Rec/Total	/Complete	0.048		pci/ml	07/23/91	13:00	********	102
142	7440-61-1	Uranium, Total	As Rec/Total	/Complete	0.005		mg/l	07/18/91	13:00	********	127
137	13966-29-5	Uranium-234	As Rec/Total	/Complete	4.7	+/-.90	pci/l	07/17/91	13:00	********	102
139		Uranium-235 Percent	As Rec/Total	/Complete	1.06	+/-0.04	%	07/18/91	13:00	********	127
141		Uranium-238	As Rec/Total	/Complete	4.0	+/-.79	pci/l	07/17/91	13:00	********	102
		ICP Sweep									
001	7429-90-5	Aluminum	As Rec/Total	/Complete	0.33		mg/l	07/22/91	15:45	200.7	099
003	7440-38-2	Arsenic	As Rec/Total	/Complete	<0.04		mg/l	07/22/91	15:45	200.7	099
004	7440-39-3	Barium	As Rec/Total	/Complete	0.0503		mg/l	07/22/91	15:45	200.7	099
006	7440-41-7	Beryllium	As Rec/Total	/Complete	<0.0004		mg/l	07/22/91	15:45	200.7	099
007	7440-42-8	Boron	As Rec/Total	/Complete	0.121		mg/l	07/22/91	15:45	200.7	099
008	7440-43-9	Cadmium	As Rec/Total	/Complete	<0.004		mg/l	07/22/91	15:45	200.7	099
009	7440-70-2	Calcium	As Rec/Total	/Complete	42.4		mg/l	07/22/91	15:45	200.7	099
010	7440-45-1	Cerium	As Rec/Total	/Complete	<0.02		mg/l	07/22/91	15:45	200.7	099

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DC	CAS NUMBER	DETERMINATION	BASIS/PREP	/PHASE	ANSWER		UNITS	DATE	TIME	METHOD	ANA
011	7440-47-3	Chromium	As Rec/Total	/Complete	<0.006		mg/l	07/22/91	15:45	200.7	099
012	7440-48-4	Cobalt	As Rec/Total	/Complete	0.007		mg/l	07/22/91	15:45	200.7	099
013	7440-50-8	Copper	As Rec/Total	/Complete	0.018		mg/l	07/22/91	15:45	200.7	099
014	7440-55-3	Gallium	As Rec/Total	/Complete	<0.02		mg/l	07/22/91	15:45	200.7	099
018	7439-89-6	Iron	As Rec/Total	/Complete	0.62		mg/l	07/22/91	15:45	200.7	099
020	7439-92-1	Lead	As Rec/Total	/Complete	<0.02		mg/l	07/22/91	15:45	200.7	099
021	7439-93-2	Lithium	As Rec/Total	/Complete	0.03		mg/l	07/22/91	15:45	200.7	099
022	7439-95-4	Magnesium	As Rec/Total	/Complete	9.17		mg/l	07/22/91	15:45	200.7	099
023	7439-96-5	Manganese	As Rec/Total	/Complete	0.087		mg/l	07/22/91	15:45	200.7	099
025	7439-98-7	Molybdenum	As Rec/Total	/Complete	<0.006		mg/l	07/22/91	15:45	200.7	099
026	7440-02-0	Nickel	As Rec/Total	/Complete	<0.008		mg/l	07/22/91	15:45	200.7	099
027	7440-03-1	Niobium	As Rec/Total	/Complete	<0.01		mg/l	07/22/91	15:45	200.7	099
030	7723-14-0	Phosphorus	As Rec/Total	/Complete	2.61		mg/l	07/22/91	15:45	200.7	099
032	7440-09-7	Potassium	As Rec/Total	/Complete	7.1		mg/l	07/22/91	15:45	200.7	099
035	7440-20-2	Scandium	As Rec/Total	/Complete	<0.0004		mg/l	07/22/91	15:45	200.7	099
038	7440-22-4	Silver	As Rec/Total	/Complete	<0.006		mg/l	07/22/91	15:45	200.7	099
039	7440-23-5	Sodium	As Rec/Total	/Complete	13.4		mg/l	07/22/91	15:45	200.7	099
040	7440-24-6	Strontium	As Rec/Total	/Complete	0.100		mg/l	07/22/91	15:45	200.7	099
042	7440-28-0	Thallium	As Rec/Total	/Complete	<0.03		mg/l	07/22/91	15:45	200.7	099
043	7440-29-1	Thorium	As Rec/Total	/Complete	<0.01		mg/l	07/22/91	15:45	200.7	099
045	7440-32-6	Titanium	As Rec/Total	/Complete	0.03		mg/l	07/22/91	15:45	200.7	099
046	7440-62-2	Vanadium	As Rec/Total	/Complete	<0.004		mg/l	07/22/91	15:45	200.7	099
048	7440-66-6	Zinc	As Rec/Total	/Complete	0.14		mg/l	07/22/91	15:45	200.7	099
049	7440-67-7	Zirconium	As Rec/Total	/Complete	<0.004		mg/l	07/22/91	15:45	200.7	099
	Gamma Activity										
152		Gamma, Total	As Rec/Total	/Complete	5.6	+/-19	pci/l	07/22/91	13:00	********	033
360		U233	As Rec/Total		None Detected Above Background						

ENDS001 Y-12 PLANT LAB ENVIRONMENTAL ANALYSES REPORT

Requisition: A35839 Env Sample Code: 8601 Sample desc: H2O 24 HR.

Sample loc: SAN.SEW.4
Date: 07-21-91
Time: 09:25

Requester name: HANZELKA ,K
Addr: 9115 ,8219,012
Phone: 4-1599

Sampled by: 30786/22559
Ref Id:

Date received: 07-22-91
Reported: 08-05-91

Handling: NEED 7/31/91

Charge code: S2211001

Remarks:

Approved by: SLAGLE /DHB

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DC	CAS NUMBER	DETERMINATION	BASIS/PREP	/PHASE	ANSWER		UNITS	DATE	TIME	METHOD	ANA
102	12587-46-1	Alpha Activity	As Rec/Total	/Complete	1.0	+/-0.2	pci/l	07/25/91	13:00	********	033
404		Ammonia, As Nitrogen	As Rec/Total	/Complete	2.4	+/-0.2	mg/l	07/25/91	15:30	350.2	116
105	12587-47-2	Beta Activity	As Rec/Total	/Complete	11	+/-2	pci/l	07/25/91	13:00	********	033
		Biochemical Oxygen Demand (BO	As Rec/Total	/Complete	8.6	+/-0.9	mg/l	07/27/91	10:00	405.1	139
		Chemical Oxygen Demand (COD)	As Rec/Total	/Complete	20	+/-3	mg/l	07/27/91	12:00	410.2	139
414	18540-29-9	Chromium, Hexavalent (Cr+6)	As Rec/Total	/Complete	<0.01		mg/l	07/22/91	08:46	218.4	134
024	7439-97-6	Mercury	As Rec/Total	/Complete	0.0007		mg/l	07/23/91	16:00	245.1	095
441		Nitrogen, Kjeldahl	As Rec/Total	/Complete	3.0	+/-0.3	mg/l	07/30/91	14:15	351.3	145
121	13981-16-3	Plutonium-238	As Rec/Total	/Complete	0.10	+/-.18	pci/l	07/24/91	13:00	********	136
122		Plutonium-239/240	As Rec/Total	/Complete	0.08	+/-.13	pci/l	07/24/91	13:00	********	136
455		Residue, Non-Filterable (TSS)	As Rec/Total	/Complete	7	+/-0.7	mg/l	07/23/91	11:00	160.2	148
036	7782-49-2	Selenium	As Rec/Total	/Complete	<0.002		mg/l	07/25/91	13:00	270.2	058
142	7440-61-1	Uranium, Total	As Rec/Total	/Complete	0.003		mg/l	07/24/91	13:00	********	127
137	13966-29-5	Uranium-234	As Rec/Total	/Complete	2.8	+/-.64	pci/l	07/25/91	13:00	********	019
139		Uranium-235 Percent	As Rec/Total	/Complete	1.17	+/-0.05	%	07/24/91	13:00	********	127
141		Uranium-238	As Rec/Total	/Complete	1.3	+/-.41	pci/l	07/25/91	13:00	********	019
	ICP Sweep										
001	7429-90-5	Aluminum	As Rec/Total	/Complete	0.36		mg/l	07/26/91	07:51	200.7	067
003	7440-38-2	Arsenic	As Rec/Total	/Complete	<0.04		mg/l	07/26/91	07:51	200.7	067
004	7440-39-3	Barium	As Rec/Total	/Complete	0.0373		mg/l	07/26/91	07:51	200.7	067
006	7440-41-7	Beryllium	As Rec/Total	/Complete	<0.0004		mg/l	07/26/91	07:51	200.7	067
007	7440-42-8	Boron	As Rec/Total	/Complete	0.086		mg/l	07/26/91	07:51	200.7	067
008	7440-43-9	Cadmium	As Rec/Total	/Complete	<0.004		mg/l	07/26/91	07:51	200.7	067
009	7440-70-2	Calcium	As Rec/Total	/Complete	39.6		mg/l	07/26/91	07:51	200.7	067
010	7440-45-1	Cerium	As Rec/Total	/Complete	<0.02		mg/l	07/26/91	07:51	200.7	067
011	7440-47-3	Chromium	As Rec/Total	/Complete	<0.006		mg/l	07/26/91	07:51	200.7	067

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DC	CAS NUMBER	DETERMINATION	BASIS/PREP	/PHASE	ANSWER		UNITS	DATE	TIME	METHOD	ANA
012	7440-48-4	Cobalt	As Rec/Total	/Complete	0.003		mg/l	07/26/91	07:51	200.7	067
013	7440-50-8	Copper	As Rec/Total	/Complete	<0.006		mg/l	07/26/91	07:51	200.7	067
014	7440-55-3	Gallium	As Rec/Total	/Complete	<0.02		mg/l	07/26/91	07:51	200.7	067
018	7439-89-6	Iron	As Rec/Total	/Complete	0.22		mg/l	07/26/91	07:51	200.7	067
020	7439-92-1	Lead	As Rec/Total	/Complete	<0.02		mg/l	07/26/91	07:51	200.7	067
021	7439-93-2	Lithium	As Rec/Total	/Complete	0.02		mg/l	07/26/91	07:51	200.7	067
022	7439-95-4	Magnesium	As Rec/Total	/Complete	9.26		mg/l	07/26/91	07:51	200.7	067
023	7439-96-5	Manganese	As Rec/Total	/Complete	0.061		mg/l	07/26/91	07:51	200.7	067
025	7439-98-7	Molybdenum	As Rec/Total	/Complete	<0.006		mg/l	07/26/91	07:51	200.7	067
026	7440-02-0	Nickel	As Rec/Total	/Complete	<0.008		mg/l	07/26/91	07:51	200.7	067
027	7440-03-1	Niobium	As Rec/Total	/Complete	<0.01		mg/l	07/26/91	07:51	200.7	067
030	7723-14-0	Phosphorus	As Rec/Total	/Complete	0.76		mg/l	07/26/91	07:51	200.7	067
032	7440-09-7	Potassium	As Rec/Total	/Complete	3.7		mg/l	07/26/91	07:51	200.7	067
035	7440-20-2	Scandium	As Rec/Total	/Complete	<0.0004		mg/l	07/26/91	07:51	200.7	067
038	7440-22-4	Silver	As Rec/Total	/Complete	<0.006		mg/l	07/26/91	07:51	200.7	067
039	7440-23-5	Sodium	As Rec/Total	/Complete	8.54		mg/l	07/26/91	07:51	200.7	067
040	7440-24-6	Strontium	As Rec/Total	/Complete	0.098		mg/l	07/26/91	07:51	200.7	067
042	7440-28-0	Thallium	As Rec/Total	/Complete	<0.03		mg/l	07/26/91	07:51	200.7	067
043	7440-29-1	Thorium	As Rec/Total	/Complete	<0.01		mg/l	07/26/91	07:51	200.7	067
045	7440-32-6	Titanium	As Rec/Total	/Complete	0.03		mg/l	07/26/91	07:51	200.7	067
046	7440-62-2	Vanadium	As Rec/Total	/Complete	<0.004		mg/l	07/26/91	07:51	200.7	067
047	7440-65-5	Yttrium	As Rec/Total	/Complete	0.192		mg/l	07/26/91	07:51	200.7	067
048	7440-66-6	Zinc	As Rec/Total	/Complete	0.06		mg/l	07/26/91	07:51	200.7	067
049	7440-67-7	Zirconium	As Rec/Total	/Complete	<0.004		mg/l	07/26/91	07:51	200.7	067
		Gamma Activity									
152		Gamma, Total	As Rec/Total	/Complete	44	+/-18	pci/l	07/24/91	13:00	********	033

ENDS001 Y-12 PLANT LAB ENVIRONMENTAL ANALYSES REPORT

Requisition: A35971 Env Sample Code: 8601 Sample desc: H2O 24 HR.

Sample loc: SAN.SEW.4
Date: 07-29-91
Time: 09:55

Requester name: HANZELKA ,K
Addr: 9115 ,8219,012
Phone: 4-1599

Sampled by: 30786/30095/30096
Ref Id:

Date received: 07-29-91
Reported: 09-19-91

Handling: NEED 8/8/91

Charge code: S2211001

Remarks:

Approved by: SLAGLE /DHB

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DC	CAS NUMBER	DETERMINATION	BASIS/PREP	/PHASE	ANSWER		UNITS	DATE	TIME	METHOD	ANA
102	12587-46-1	Alpha Activity	As Rec/Total	/Complete	7.8	+/-1	pci/l	08/01/91	13:00	********	033
404		Ammonia, As Nitrogen	As Rec/Total	/Complete	3.1	+/-0.3	mg/l	07/31/91	14:13	350.2	145
3	12587-47-2	Beta Activity	As Rec/Total	/Complete	16	+/-2	pci/l	08/01/91	13:00	********	033
407		Biochemical Oxygen Demand (BO	As Rec/Total	/Complete	7.76	+/-0.8	mg/l	08/03/91	09:30	405.1	139
109	10045-97-3	Cesium-137	As Rec/Total	/Complete	-1.6	+/-1.3	pci/l	09/17/91	13:00	********	018
411		Chemical Oxygen Demand (COD)	As Rec/Total	/Complete	<5		mg/l	07/30/91	14:30	410.2	139
414	18540-29-9	Chromium, Hexavalent (Cr+6)	As Rec/Total	/Complete	0.01		mg/l	07/30/91	09:56	218.4	134
113	10198-40-0	Cobalt-60	As Rec/Total	/Complete	-1.8	+/-1.3	pci/l	09/17/91	13:00	********	018
024	7439-97-6	Mercury	As Rec/Total	/Complete	0.0017		mg/l	07/31/91	15:20	245.1	095
119		Neptunium-237	As Rec/Total	/Complete	0.02	+/-.04	pci/l	08/05/91	13:00	********	102
441		Nitrogen, Kjeldahl	As Rec/Total	/Complete	4.2	+/-0.4	mg/l	08/06/91	13:00	351.3	145
121	13981-16-3	Plutonium-238	As Rec/Total	/Complete	0.06	+/-.14	pci/l	08/09/91	13:00	********	136
122		Plutonium-239/240	As Rec/Total	/Complete	-.01	+/-.08	pci/l	08/09/91	13:00	********	136
455		Residue, Non-Filterable (TSS)	As Rec/Total	/Complete	14	+/-1	mg/l	07/31/91	01:30	160.2	148
036	7782-49-2	Selenium	As Rec/Total	/Complete	<0.002		mg/l	07/31/91	21:00	270.2	058
134	7440-29-1	Thorium, Total	As Rec/Total	/Complete	<0.003		mg/l	08/01/91	13:00	********	136
142	7440-61-1	Uranium, Total	As Rec/Total	/Complete	0.005		mg/l	08/04/91	13:00	********	102
137	13966-29-5	Uranium-234	As Rec/Total	/Complete	5.1	+/-1.0	pci/l	08/06/91	13:00	********	136
139		Uranium-235 Percent	As Rec/Total	/Complete	0.95	+/-0.04	%	08/04/91	13:00	********	102
141		Uranium-238	As Rec/Total	/Complete	2.6	+/-.66	pci/l	08/06/91	13:00	********	136
	ICP Sweep										
001	7429-90-5	Aluminum	As Rec/Total	/Complete	0.22		mg/l	07/31/91	13:03	200.7	067
003	7440-38-2	Arsenic	As Rec/Total	/Complete	<0.04		mg/l	07/31/91	13:03	200.7	067
004	7440-39-3	Barium	As Rec/Total	/Complete	0.0535		mg/l	07/31/91	13:03	200.7	067
006	7440-41-7	Beryllium	As Rec/Total	/Complete	<0.0004		mg/l	07/31/91	13:03	200.7	067
7	7440-42-8	Boron	As Rec/Total	/Complete	0.079		mg/l	07/31/91	13:03	200.7	067

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DC	CAS NUMBER	DETERMINATION	BASIS/PREP	/PHASE	ANSWER		UNITS	DATE	TIME	METHOD	ANA
008	7440-43-9	Cadmium	As Rec/Total	/Complete	<0.004		mg/l	07/31/91	13:03	200.7	067
009	7440-70-2	Calcium	As Rec/Total	/Complete	41.7		mg/l	07/31/91	13:03	200.7	067
010	7440-45-1	Cerium	As Rec/Total	/Complete	<0.02		mg/l	07/31/91	13:03	200.7	067
011	7440-47-3	Chromium	As Rec/Total	/Complete	<0.006		mg/l	07/31/91	13:03	200.7	067
012	7440-48-4	Cobalt	As Rec/Total	/Complete	0.004		mg/l	07/31/91	13:03	200.7	067
013	7440-50-8	Copper	As Rec/Total	/Complete	0.011		mg/l	07/31/91	13:03	200.7	067
014	7440-55-3	Gallium	As Rec/Total	/Complete	<0.02		mg/l	07/31/91	13:03	200.7	067
018	7439-89-6	Iron	As Rec/Total	/Complete	0.43		mg/l	07/31/91	13:03	200.7	067
020	7439-92-1	Lead	As Rec/Total	/Complete	<0.02		mg/l	07/31/91	13:03	200.7	067
021	7439-93-2	Lithium	As Rec/Total	/Complete	<0.02		mg/l	07/31/91	13:03	200.7	067
022	7439-95-4	Magnesium	As Rec/Total	/Complete	9.16		mg/l	07/31/91	13:03	200.7	067
023	7439-96-5	Manganese	As Rec/Total	/Complete	0.069		mg/l	07/31/91	13:03	200.7	067
025	7439-98-7	Molybdenum	As Rec/Total	/Complete	<0.006		mg/l	07/31/91	13:03	200.7	067
026	7440-02-0	Nickel	As Rec/Total	/Complete	<0.008		mg/l	07/31/91	13:03	200.7	067
027	7440-03-1	Niobium	As Rec/Total	/Complete	<0.01		mg/l	07/31/91	13:03	200.7	067
030	7723-14-0	Phosphorus	As Rec/Total	/Complete	1.13		mg/l	07/31/91	13:03	200.7	067
032	7440-09-7	Potassium	As Rec/Total	/Complete	3.0		mg/l	07/31/91	13:03	200.7	06.
035	7440-20-2	Scandium	As Rec/Total	/Complete	<0.0004		mg/l	07/31/91	13:03	200.7	067
038	7440-22-4	Silver	As Rec/Total	/Complete	<0.006		mg/l	07/31/91	13:03	200.7	067
039	7440-23-5	Sodium	As Rec/Total	/Complete	7.70		mg/l	07/31/91	13:03	200.7	067
040	7440-24-6	Strontium	As Rec/Total	/Complete	0.104		mg/l	07/31/91	13:03	200.7	067
042	7440-28-0	Thallium	As Rec/Total	/Complete	<0.03		mg/l	07/31/91	13:03	200.7	067
043	7440-29-1	Thorium	As Rec/Total	/Complete	<0.01		mg/l	07/31/91	13:03	200.7	067
045	7440-32-6	Titanium	As Rec/Total	/Complete	0.02		mg/l	07/31/91	13:03	200.7	067
046	7440-62-2	Vanadium	As Rec/Total	/Complete	<0.004		mg/l	07/31/91	13:03	200.7	067
048	7440-66-6	Zinc	As Rec/Total	/Complete	0.13		mg/l	07/31/91	13:03	200.7	067
049	7440-67-7	Zirconium	As Rec/Total	/Complete	<0.004		mg/l	07/31/91	13:03	200.7	067
		Gamma Activity									
152		Gamma, Total	As Rec/Total	/Complete	200	+/-19	pci/l	07/30/91	13:00	********	018

APPENDIX I

Table 2.2.4. 1988 annual summary for station 17 influent radiological data[a]

Parameter	No. samples	Concentration (mg/L)			Std. error	% DCG
		Max	Min	Av		
Uranium	4	0.036	0.02	0.03	0.004	NA[b]
Thorium	2	0.65	0.005	0.33	0.32	NA

[a]Sampling period is Nov.–Dec. 1988.
[b]NA = not applicable.

Table 2.2.5. 1988 annual radiological summary for West End Sanitary Sewer

Parameter	No. samples	Concentration[a]			Std. error	% DCG
		Max	Min	Av		
Alpha (pCi/L)	9	190	4.6	80	23.4	NA[a]
Beta (pCi/L)	9	240	12	90	30.0	NA
^{238}Pu (pCi/L)	8	0.61	0	0.11	0.07	0.28
^{235}U (pCi/L)	9	2.5	<0	<0.4	0.27	0.07
^{235}U (%)	9	5.43	0.72	1.71	0.48	NA
Uranium	9	0.023	0.002	0.011	0.003	NA

[a]All units are in mg/L unless noted otherwise.
[b]NA = not applicable.

Table 2.2.6. 1988 annual radiological summary for East End Sanitary Sewer

Parameter	No. samples	Concentration[a]			Std. error	% DCG
		Max	Min	Av		
Alpha (pCi/L)	22	1000	0	96	10.1	NA[b]
Beta (pCi/L)	22	160	0	52	8.3	NA
^{238}Pu (pCi/L)	22	0.3	0	0.06	0.02	0.18
^{235}U (pCi/L)	22	2.5	0	0.13	0.11	0.03
^{235}U (%)	22	2.72	0.07	1.0	0.095	NA
Uranium	22	0.01	0.001	0.003	0.0005	NA

[a]All units are in mg/L unless noted otherwise.
[b]NA = not applicable.

Table 2.2.4. 1989 Annual radiological summary for West End Sanitary Sewer

Parameter	No. samples	Concentration[a]			Std. error	% DCG
		Max	Min	Av		
Alpha, pCi/L	12	200.0	0.0	41.3	15.2	*b*
Beta, pCi/L	12	70.0	0.0	32.6	5.4	*b*
^{238}Pu, pCi/L	3	1.0	0.0	0.33	0.33	0.83
^{235}U (%)	12	6.96	0.89	2.33	0.58	*b*
Uranium	12	0.035	0.004	0.013	0.003	*b*

[a]Units are in mg/L unless otherwise noted.
[b]Not applicable.

Table 2.2.5. 1989 Annual radiological summary for East End Sanitary Sewer

Parameter	No. samples	Concentration[a]			Std. error	% DCG
		Max	Min	Av		
Alpha, pCi/L	12	110.0	−1.9	29.0	11.8	*b*
Beta, pCi/L	12	110.0	4.6	34.7	10.1	*b*
^{238}Pu, pCi/L	3	0.19	0.0	0.06	0.06	0.15
^{235}U (%)	12	3.06	0.11	0.97	0.23	*b*
Uranium	12	0.003	0.001	0.002	0.0002	*b*

[a]Units are in mg/L unless otherwise noted.
[b]Not applicable.

Table 2.2.6. Y-12 Plant release of uranium to the off-site environment as a liquid effluent

Year	Uranium (Ci)	Uranium (Kg)
	Station 17	
1988	0.164	220
1989	0.20	316
	Outfall 304	
1988	0.052	94
1989	0.138	244
	Total off-site release	
1988	0.22	314
1989	0.34	540

from process discharge point sources. and from various other outfalls. Table 2.2.7 contains a summary of the current locations, parameters analyzed, and frequencies of sample collection and analysis for all radiological samples (except category I and II outfall samples). Results from the first three types of locations are summarized in this section. Results from the process points analyses and the categories I and II analyses are deferred to Sect. 2.2.2, NPDES Monitoring Program, which also contains results for three stream locations covered by the permit. Differences between the current sampling and analysis schedule presented in Table 2.2.7 and the schedule followed earlier in the year are described as the results are presented.

Treated water samples are collected weekly at the Kingston and ORGDP (Gallaher) potable water treatment plants (Fig. 2.2.3) and are analyzed quarterly. In addition, flow-proportional samples are collected weekly at Melton Hill Dam (MHD) (Fig. 2.2.3) and analyzed monthly. This sampling location, which is on the Clinch River, is above ORNL's discharge point to the Clinch River (with the exception of the cooling tower, roof and parking lot runoff at the 7600 area) and serves as a local background or reference station.

Table 3.4. 1990 annual radiological summary for West End Sanitary Sewer

Parameter	Number of samples	Concentration				% DCG
		Max	Min	Av	Standard error	
Alpha, pCi/L	12	42.0	6.8	21.9	3.13	a
Beta, pCi/L	12	56.0	13.0	28.9	4.28	a
^{235}U (%)	12	6.20	1.07	1.97	0.410	a
Uranium (total), mg/L	12	0.0120	0.002	0.006	0.0008	a
Gamma, pCi/L	12	570	7	153	55.2	a

[a]Not applicable.

Table 3.5. 1990 annual radiological summary for East End Sanitary Sewer

Parameter	Number of samples	Concentration				% DCG
		Max	Min	Av	Standard error	
Alpha, pCi/L	12	26	2.9	7.9	1.86	a
Beta, pCi/L	12	26	7.3	17.4	1.87	a
^{235}U (%)	11	6.3	<0.34	<1.92	0.572	a
Uranium (total), mg/L	12	0.013	<0.001	<0.003	0.0010	a
Gamma, pCi/L	12	340	15	93	28.3	a

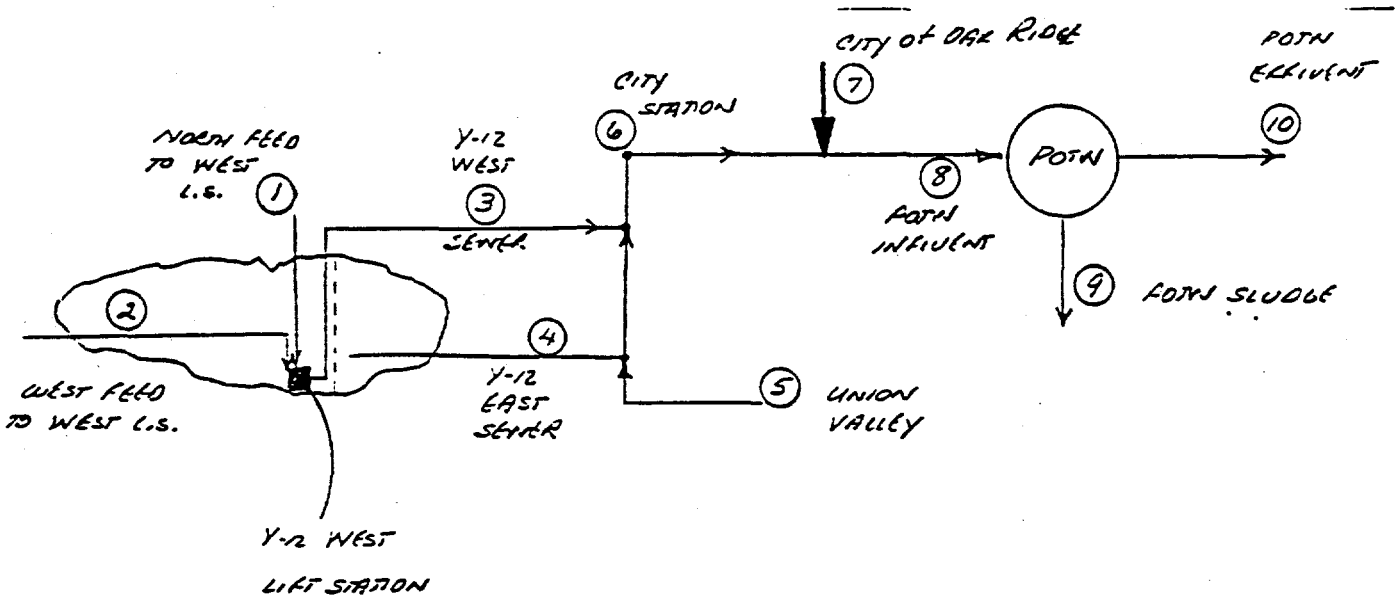
[a]Not applicable.

Table 3.6. Y-12 Plant release of uranium to the off-site environment as a liquid effluent

Year	Uranium (Ci)	Uranium (kg)
	Station 17	
1988	0.164	220
1989	0.20	316
1990	0.135	197
	Outfall 304	
1988	0.052	94
1989	0.138	244
1990	0.131	204
	Total off-site release	
1988	0.22	314
1989	0.34	560
1990	0.27	401

APPENDIX J

Y-12 Sanitary Sewer Mass Balance Calculations



ASSUMPTIONS

Flow Rates

1. The POTW influent flow rate is 5.2 MGD. (From discussions with the POTW operator - Jack Robinson)

2. The Y-12 Plant sanitary wastewater flow rate is 1.0 MGD. (From billing data for 1989, 1990, and 1991 supplied by the City of Oak Ridge.)

3. 15 percent of the sewage that comes from Y-12 is from the east end; 85 percent is from the west end. (From flow measurements obtained by the Development Division during a study in 1989. Contact - Jennings Cline)

4. Of the sanitary wastewater that flows into the Y-12 West End Lift Station, one-third originates in the north section of the west end and two-thirds originates from the west and south section of the west end. (From observations by sampling technicians during a November, 1990 sewer sampling study coordinated by Y.C. Childs (Development).)

5. The sanitary wastewater flow rate at the City Station is 1.659 MGD. (From City Station flow data for 1990 supplied by K.G. Hanzelka.)

6. The POTW sludge withdrawal rate is 73,678 dry lbs/mo. (From Uranium in Oak Ridge Sewage Sludge, provided by H.L. Boston, for 1990.)

7. The POTW sludge that is removed from the digesters for disposal contains 2.5 percent solids. The flow rate of sludge removed by the city is assumed to be continuous and the sludge is assumed to have the density of water.

These assumptions allow the flow rates for all the streams shown on page 1 to be calculated.

Uranium Concentrations and ^{235}U Assays

1. Uranium concentrations and assays for sanitary sewage originating at Y-12 are:

	U	^{235}U
Y-12 West Sewer		
North Side	0.006 mg/l	1.74 %
West Side	0.027 mg/l	0.41 %
Y-12 East Sewer	0.002 mg/l	0.83 %

(From samples taken by sampling technicians during a November, 1990 sewer sampling study coordinated by Y.C. Childs (Development).)

2. The uranium concentration in the Union Valley stream is 0.0 mg/l with an assay 0.177 % ^{235}U. (0.0 mg/l is a worst case assumption for this study. The assay of 0.177 % is from the 1989 Development Division study conducted by J.E. Cline.)

3. No uranium is contributed by other users of the city facility. (A worst case assumption.)

4. No uranium is discharged in the POTW effluent. (A worst case assumption.)

These assumptions about the uranium and ^{235}U concentrations in the Y-12/POTW system allow the calculation of U and ^{235}U concentrations and mass loading throughout the remainder of the system.

Configuration of the POTW System

1. Volumes for the POTW equipment were obtained via telephone conversation with City of Oak Ridge wastewater treatment personnel. To approximate a worst case situation, all vessels were assumed to be full. In reality, the digesters are operated at one-half to three-quarters of their capacity.

COMMENTS ON CALCULATIONS

The attached spreadsheet represents the steady-state material balance calculated for the Y-12 and POTW sewer systems. At least two sources of data independent of the data used in the assumptions above verify the calculation and provide a degree of confidence that it is in the ball park. They are:

1. Results for uranium and ^{235}U obtained at the City Station by the Y-12 Environmental Monitoring Department during 1990 indicate that the average mass flow rate of uranium at the city station is approximately 41 gm/day. The calculated result is 43 gm/day.

2. Measurements of uranium in the sludge removed from the POTW indicate that approximately 43 gm/day of sludge is removed from the city facility, providing a second confirmation of the result in Item 1 above.

3. Measurements of U in the POTW sludge during late 1990 and early 1991 indicate that the average concentration of uranium in the sludge was 1.14 mg U/l during that period, compared to a calculated value of 0.98 mg/l. Similarly, measurements of ^{235}U in the sludge for the same period yielded an average value of 0.835 % compared to a calculated value of 0.82 %.

There are other data with which the model are not particularly consistent. For the most part they involve the uranium and ^{235}U values assumed for the east and west Y-12 sanitary sewage streams.

In summarizing the results of this material balance, the key results from the viewpoint of discharges of uranium from Y-12 and the resulting impact on the POTW are: the assay of ^{235}U in the city sludge, and the total mass of U and ^{235}U in the POTW facility. In general, the ^{235}U content in the POTW is influenced by the ratio of enriched to depleted uranium streams in the system. Changes in North Feed to the Y-12 West Lift Station are most influential because it is more enriched than the depleted streams are depleted. The role of the Union Valley stream may be important if it contains uranium. The assumption that the Union Valley stream contains no uranium is conservative from the viewpoint of estimating the maximum contribution of Y-12 uranium to the POTW. However, if the assumption is wrong and the Union Valley stream contains depleted uranium, then its role in "doping" the assay of the Y-12 stream is not accounted for. Consequently, the assay of the Y-12 stream would be higher than estimated by the model, although the amount of uranium and ^{235}U in the POTW would remain the same.

Submitted by John Prazniak 6/27/91
Y-12 Waste Management Engineering

Y-12 SANITARY SEWER URANIUM MASS BALANCE

06/26/91

	Stream 1	Stream 2	Stream 3	Stream 4	Stream 5	Stream 6	Stream 7	Stream 8	Stream 9	Stream 10
	North Feed to West L.S.	West Feed to West L.S.	Y-12 West Sewer	Y-12 East Sewer	Union Valley	City Station	Balance of City	POTW Influent	POTW Sludge	POTW Effluent
Flow (GPM)	393.715278	196.562500	590.277778	104.166667	458.000000	1152.444444	2458.555556	3611.000000	8.067847	3602.932153
Flow (MGD)	0.566950	0.283050	0.850000	0.150000	0.659520	1.659520	3.540320	5.199840	0.011618	5.188222
Total U (Mg/L)	0.006000	0.027000	0.012993	0.002000	0.000000	0.006836	0.000000	0.002182	0.976445	0.000000
U235 (%)	1.740000	0.410000	0.819656	0.830000	0.177000	0.819930	0.000000	0.819930	0.819930	0.819930
U Flow (gm/day)	12.875435	28.926295	41.801729	1.135500	0.000000	42.937229	0.000000	42.937229	42.937229	0.000000
U235 Flow (gm/day)	0.224033	0.118598	0.342630	0.009425	0.000000	0.352055	0.000000	0.352055	0.352055	0.000000

Specified variables:

Fraction of Y-12 Flow attributed to East End		0.150000
Fraction of uranium in influent that passes through city facility:		0.000000
Y-12 Sanitary Wastewater Flow (MGD)		1.000000
Union Valley flow (gpm)		458.000000 GPM
City sludge disposal rate		73678.000000 lbs/mo @ 2.5% solids
U and U235 for Stream 1	0.006000 mg/l	1.740000 % U235
for Stream 2	0.027000 mg/l	0.410000 % U235
for Stream 4	0.002000 mg/l	0.830000 % U235
for Stream 5	0.000000 mg/l	0.177000 % U235

POTW Uranium Inventory:

	Volume	Concentration	Mass U (Gms)	Mass U235 (Gms)
Screening Chamber Grit Tanks Primary Settlers	1000000.000000	Influent	8.257414	0.067705
Aeration Chambers	1200000.000000	Influent	9.908896	0.081246
Secondary Settlers	1200000.000000	Influent	9.908896	0.081246
Filters	200000.000000	Effluent	0.000000	0.000000
Chlorine contactors	200000.000000	Effluent	0.000000	0.000000
Digesters	1100000.000000	Sludge	4065.430587	33.333666
Total	4900000.000000		4093.505794	33.563863

APPENDIX K

01

Y-12 PLANT LAB ENVIRONMENTAL ANALYSES REPORT

Requisition: A34128 Env Sample Code: 8402 Sample desc: SLUDGE

Sample loc: MULTIPLE
Date: 06-12-91
Time: 15:04

Requester name: HANZELKA
Addr: 9115 ,8219,0
Phone: 4-1599

Sampled by: 14224
Ref Id: 1106

Date received: 06-12-91
Reported: 06-17-91

Handling: RUSH

Charge code: S2211401

Remarks:

Approved by: WHITELE /DJP

****

OC	CAS NUMBER	DETERMINATION	BASIS/PREP	/PHASE	ANSWER	UNITS	DATE	TIME	METHOD	ANA
Sample: 001 Location: DRIED SLUDGE 4/14-4/20/89										
142	7440-61-1	Uranium, Total	As Rec/Total	/Complete	98.9	ug/g	06/13/91	13:00	********	102
139		Uranium-235 Percent	As Rec/Total	/Complete	0.59	%	06/13/91	13:00	********	102
Sample: 002 Location: DRIED SLUDGE 11/18-11/23/83										
142	7440-61-1	Uranium, Total	As Rec/Total	/Complete	290	ug/g	06/13/91	13:00	********	102
39		Uranium-235 Percent	As Rec/Total	/Complete	0.37	%	06/13/91	13:00	********	102
Sample: 003 Location: DRIED SLUDGE 11/16-11/22/90										
142	7440-61-1	Uranium, Total	As Rec/Total	/Complete	59.0	ug/g	06/13/91	13:00	********	102
139		Uranium-235 Percent	As Rec/Total	/Complete	0.87	%	06/13/91	13:00	********	102
Sample: 004 Location: DIRED SLUDGE 1/20-1/26/89										
142	7440-61-1	Uranium, Total	As Rec/Total	/Complete	173	ug/g	06/13/91	13:00	********	102
139		Uranium-235 Percent	As Rec/Total	/Complete	0.45	%	06/13/91	13:00	********	102
Sample: 005 Location: DRIED SLUDGE 7/14-7/20/89										
142	7440-61-1	Uranium, Total	As Rec/Total	/Complete	144	ug/g	06/13/91	13:00	********	102
139		Uranium-235 Percent	As Rec/Total	/Complete	0.45	%	06/13/91	13:00	********	102
Sample: 006 Location: DRIED SLUDGE 3/1-3/7/91										
142	7440-61-1	Uranium, Total	As Rec/Total	/Complete	32.9	ug/g	06/13/91	13:00	********	102
139		Uranium-235 Percent	As Rec/Total	/Complete	0.80	%	06/13/91	13:00	********	102

Y-12 PLANT LAB ENVIRONMENTAL ANALYSES REPORT

Acquisition: A34128

****

DC	CAS NUMBER	DETERMINATION	BASIS/PREP	/PHASE	ANSWER	UNITS	DATE	TIME	METHOD	ANA
Sample: 007 Location: DIRED SLUDGE 10/7-10/13/88										
142	7440-61-1	Uranium, Total	As Rec/Total	/Complete	268	ug/g	06/13/91	13:00	********	102
139		Uranium-235 Percent	As Rec/Total	/Complete	0.27	%	06/13/91	13:00	********	102
Sample: 008 Location: DIGESTED SLUDGE 7/10-7/12/90										
142	7440-61-1	Uranium, Total	As Rec/Total	/Complete	56.5	ug/g	06/13/91	13:00	********	102
139		Uranium-235 Percent	As Rec/Total	/Complete	0.68	%	06/13/91	13:00	********	102
Sample: 009 Location: DIGESTED SLUDGE 5/25-5/31/90										
142	7440-61-1	Uranium, Total	As Rec/Total	/Complete	55.3	ug/g	06/13/91	13:00	********	10?
139		Uranium-235 Percent	As Rec/Total	/Complete	0.66	%	06/13/91	13:00	********	102
Sample: 010 Location: SLUDGE 9/29-10/5/89										
	7440-61-1	Uranium, Total	As Rec/Total	/Complete	56.2	ug/g	06/13/91	13:00	********	102
		Uranium-235 Percent	As Rec/Total	/Complete	0.55	%	06/13/91	13:00	********	102
Sample: 011 Location: SLUDGE 1/26-2/1/90										
142	7440-61-1	Uranium, Total	As Rec/Total	/Complete	64.2	ug/g	06/13/91	13:00	********	102
139		Uranium-235 Percent	As Rec/Total	/Complete	0.62	%	06/13/91	13:00	********	102

APPENDIX L

Sanitary Sewer Special Study Data

Total Uranium (mg/l	6/6/91	6/7/91	6/11/91	6/12/91	6/13/91	6/15/91	6/16/91	6/17/91	6/18/91	6/19/91	6/20/91	6/21/91	6/22/91	6/23/91
Location														
Union Valley	0.005	0.002	0.004	0.004	0.004	0.003	0.002	0.002	0.004	0.004	0.003	0.013	0.002	0.002
City Flow Station	0.005	0.009	0.01	0.013	0.009	0.011	0.005	0.003	0.007	0.005	0.004	0.006	0.007	0.005
City Plant In								0.004	0.006	0.003	0.005	0.007		
City Plant Out								0.002	0.003	0.001	0.002	0.001		
XU-235	6/6/91	6/7/91	6/11/91	6/12/91	6/13/91	6/15/91	6/16/91	6/17/91	6/18/91	6/19/91	6/20/91	6/21/91	6/22/91	6/23/91
Location														
Union Valley	0.57	1.3	0.58	0.62	0.67	0.74	0.58	0.61	0.53	0.7	0.76	0.47	0.6	0.56
City Flow Station	1.22	1.35	1.31	1.17	1	0.55	1.06	1.4	0.84	1.27	1.71	0.79	0.92	0.68
City Plant In								0.61	0.51	0.73	0.7	0.79		
City Plant Out								0.59	0.45	0.61	0.58	0.86		
Mercury (mg/l)	6/6/91	6/7/91	6/11/91	6/12/91	6/13/91	6/15/91	6/16/91	6/17/91	6/18/91	6/19/91	6/20/91	6/21/91	6/22/91	6/23/91
Location														
Union Valley		<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0003	0.0002	0.0003	<0.0002	<0.0002	<0.0002
City Flow Station		0.0003	0.0009	0.0012	0.0041	0.0013	0.0006	0.0007	0.0003	0.0004	0.0006	0.0015	0.001	0.0002
City Plant In								0.0004	0.0004	0.0004	0.0004	0.0004		
City Plant Out								0.0002	<0.0002	0.0003	<0.0002	<0.0002		
Zinc (mg/l)	6/6/91	6/7/91	6/11/91	6/12/91	6/13/91	6/15/91	6/16/91	6/17/91	6/18/91	6/19/91	6/20/91	6/21/91	6/22/91	6/23/91
Location														
Union Valley		0.09	0.02	0.01	0.11	0.01	<0.01	<0.01	0.02	0.05	0.08	<0.01	0.03	<0.01
City Flow Station		0.2	0.15	0.19	0.11	0.1	0.1	0.08	0.08	0.1	0.12	0.13	0.14	0.06
City Plant In								0.11	0.13	0.11	0.11	0.15		
City Plant Out								0.02	0.03	0.03	0.03	0.04		

APPENDIX M

MARTIN MARIETTA

Internal Correspondence

MARTIN MARIETTA ENERGY SYSTEMS, INC.

July 1, 1991

S. Duke

Nuclear Criticality Safety Assessment of Sanitary Sewer System

The Environmental Management Department requested that the Nuclear Criticality Safety Department assess uranium losses from the Oak Ridge Y-12 Plant sanitary sewer system for potential criticality hazard.

Information provided as bases for this assessment were

(1) the attached uranium release data for November 1988 to March 1991, and

(2) a conclusion that the uranium inventory in the Publicly Owned Treatment Works (POTW) at any one time will not exceed 40 g ^{235}U contained in a total of 5,000 g uranium.

From a technical standpoint, the uranium must be regarded as "enriched uranium" since both pieces of information agree that the average ^{235}U enrichment is slightly above natural isotopic abundance of 0.71 percent ^{235}U. However, the average uranium enrichment does not exceed 0.93 percent ^{235}U, which is the subcritical limit provided in the American National Standard for Nuclear Criticality Safety in Operations with Fissionable Material Outside Reactors, ANSI/ANS-8.1 (reaffirmed November 1988).

Based on the supplied information, there is no criticality safety concern for such losses of uranium from the Oak Ridge Y-12 Plant to the sanitary sewer system.

R. G. Vornehm, 9115, MS 8223 (6-2289)

RGV:mw

Nuclear Criticality Safety Assessment of Sanitary Sewer System

On July 1, 1991, NCSD issued a letter to the Environmental Management Department that there is no criticality safety concern for losses of uranium from the Y-12 Plant to the sanitary sewer system, based on the furnished information as attached in that letter. The conclusion of no criticality hazard was drawn from the average uranium enrichment reviewed not exceeding 0.93 wt % U^{235} which is the subcritical U^{235} enrichment limit for uranium mixed homogeneously with water.

It is my understanding that you have a question on the July 1, 1991 letter: What if the average uranium enrichement exceeds the 0.93 wt % U^{235} subcritical limit ? From a technical standpoint, a maximum subcritical concentration for a uniform uranium aqueous solution can reach up to 11.6 gU^{235}/l. Considering a large, infinite system such as the Sanitary Sewer System, a discharge of a quantity of uranium into the system is expected to be diluted. Even if the average uranium enrichment exceeds the above limit, the corresponding concentration would be very low due to the dilution effect. For a concentration of less than 11.6 gU^{235}/l of aqueous solution, the effect of hydrogen capture of neutron predominates over all other effects present in the system. This effect thus makes the critical mass infinite, and it is not available in such a system. I hope this generic description will help you to answer the above concern. Nevertheless, this is what we need to do: If the average U^{235} enrichment exceeds the subcritical limit, NCSD should be notified and provided with corresponding uranium concentration data for proper review.

APPENDIX N

MARTIN MARIETTA

Internal Correspondence

MARTIN MARIETTA ENERGY SYSTEMS, INC.

June 17, 1991

S. T. Duke

Health Physics Aspects of Sanitary Sewer Discharges

Attached are calculations you requested concerning uranium in the effluent from the Y-12 Plant sanitary sewer system.

The DCGs for internal exposure in DOE Order 5400.5 are based on a committed effective dose equivalent of 100 mrem for the radionuclide taken into the body by ingestion during one year. Based upon the attached calculations and the assumptions on which they are based, it is unlikely that exposures to workers at the Oak Ridge sewage treatment plant would exceed the limit of 100 mrem/year for exposures to the public.

If I can be of further assistance, please call.

J. D. Gass II, Bldg. 9711-1, MS 8105 (6-1599)
Radiological Engineering

JDG:rwl

cc: C. C. Hill
J. B. Hunt
J. E. Stone
S. M. Trotter
L. O. Vaughn

The Question of Enriched Uranium in The Sanitary Sewer System.

The following calculations were performed by the Y-12 Radiological Engineering Section in response to inquiries concerning the amounts of uranium in the sanitary sewer and whether or not the Y-12 Plant was in compliance with the provisions for Sanitary Sewer Discharges outlined in DOE Order 5400.5, "Radiation Protection of the Public and the Environment."

1) DOE Order 5400.5, Section II.3.d, addresses "Discharges of Liquid Waste to Sanitary Sewerage."

> "The BAT selection process shall be implemented if liquid wastes discharged from DOE activities into sanitary sewerage contain radionuclides a concentrations, averaged monthly, would otherwise be greater that five times the DCG values for liquids given in Chapter III at the point of discharge. That is, the BAT selection process shall be implemented if the total of the fractions of the average concentrations for each radionuclide to its respective DCG value would otherwise exceed 5.

2) DOE Order 5400.5, Section III, Figure III-1, lists "Derived Concentration Guides (DCGs) for Members of the Public from Ingested Water and Inhalation Resulting in 100 mrem/y." Values for Ingested water containing Uranium are as follow:

U-238	6×10^{-7} μCi/ml	for D and W class
	6×10^{-6} μCi/ml	for Y class
U-235	6×10^{-7} μCi/ml	for D and W class
	5×10^{-6} μCi/ml	for Y class.

Using the most restrictive DCG for each isotope of 6×10^{-7} μCi/ml, 5 times the DCG is 3×10^{-6}. Thus, 3×10^{-6} μCi/ml is the value, below which BAT does not have to be applied.

2) The average Uranium content in the Sanitary Sewer Discharges from the Y-12 Plant, as reported in the Oak Ridge Environmental Report, Vol. 1 -- 1990, p.61, are as follows:

	West End Sanitary Sewer	East End Sanitary Sewer
Uranium, total (mg/l)	0.006	<0.003
U-235 (%)	1.97	<1.92

3) Utilizing the West End Sanitary Sewer Data as the most restrictive case, the specific activity of 1.97% enriched Uranium is:

$(0.4 + 0.38(1.97) + 0.0034(1.97)^2) \times 10^{-6}$ Ci/g $= 1.16 \times 10^{-6}$ Ci/g

4)Calculating the concentration discharge using the same data yields:

$(1.16 \times 10^{-6}$ Ci/g) x (g/ 10^3 mg) x (10^6 μCi/Ci) x (0.006 mg/l) x (l/10^3 ml) $= 6.96 \times 10^{-9}$ μCi/ml

5) The concentration of uranium in the Y-12 discharge to the Sanitary Sewer is approximately three orders of magnitude below the 3×10^{-6} μCi/ml specified by DOE Order 5400.5.

The following calculations were performed by the Y-12 Radiological Engineering Section in response to inquiries concerning the amounts of uranium in the sanitary sewer and whether or not the Y-12 Plant was in compliance with the provisions for Sanitary Sewer Discharges outlined in 10 CFR 20, "Standards for Protection Against Radiation."

1) 10 CFR 20, § 20.203 addresses "Disposal by release into sanitary sewerage systems." The section states that "no licensee shall discharge licensed material into a sanitary sewerage system unless:"

a) It is readily soluble or dispersible in water; and

b) The quantity of any licensed or other radioactive material released into the system by the licensee in any one day does not exceed the larger of [(8×10^{-4} μCi/ml) x the daily flow] or [0.1 μCi/day]; and

c) The quantity of any licensed of other radioactive material released in any one month... will not result in an average concentration exceeding 8×10^{-4} μCi/ml; and

d) The gross quantity of licensed and other radioactive material... does not exceed one curie per year.

2) As a point of comparison of Y-12 information with these NRC criteria, following information is provided.

a) Solubility and dispersability is assumed in the calculations.

b) As calculated previously, the average concentration of uranium in the Y-12 Sanitary Sewer discharge is 6.96×10^{-9} μCi/ml. Assuming an average daily flow of 10^6 gallons:

$$(6.96 \times 10^{-9}\ \mu Ci/ml) \times (10^6 gal/day) \times (3785 ml/gal) = 26.3\ \mu Ci/day$$

Compared to the NRC limit of:

$$(8 \times 10^{-4}\ \mu Ci/ml) \times (10^6 gal/day) \times (3785 ml/gal) = 3.03 \times 10^6\ \mu Ci/day$$

c) Monthly data was not provided, and therefore, the annual average data was used for comparison.

Concentration for a Month = Concentration for the year = 6.96×10^{-9} μCi/ml

This is approximately four orders of magnitude below the NRC limit of 8×10^{-4} μCi/ml.

d) Multiplying the daily amount obtained in (b) above by 365 days/year

$$26.3\ \mu Ci/day \times 365\ day/yr = 9.62 \times 10^3\ \mu Ci/year = 9.62 \times 10^{-3}\ Ci/year$$

This is less than the NRC annual limit of 1 Ci/year.

The revised 10 CFR 20 which was issued on May 21, 1991, with an effective date of June 20,1991, has slightly lower limits for sanitary sewage discharge (3×10^{-6} μCi/ml). These are, basically the same as those in DOE 5400.5 and do not affect the outcome of this analysis.

d) The gross quantity of licensed and other radioactive material released into the sewerage system is calculated as follows:

From the 1990 Environmental surveillance report

Y-12 Plant West End Sanitary Sewer

Average Alpha Activity - 21.9 pCi/L
Average Beta Activity - 28.9 pCi/L
Average Gamma Activity - 153 pCi/L

Y-12 Plant East End Sanitary Sewer

Average Alpha Activity - 7.9 pCi/L
Average Beta Activity - 17.4 pCi/L
Average Gamma Activity - 93.0 pCi/L

Combining the above values for average activity and using the average daily flow obtained from the attached chart results in the gross quantity of radioactive materials released into the sanitary sewerage system:

Average:

Alpha - (29.8 pCi/L)(3320703.14 L/day)(365 days/yr)(1E-12)
= 0.036 Ci/yr
Beta - (46.3 pCi/L)(0.001212) = 0.056 Ci/yr
Gamma - (246 pCi/L)(0.001212) = 0.298 Ci/yr

Total - 0.4 Ci/yr

Calculated Sanitary Sewer Values for 1989 and 1990

		avg
date		
Corrected data		
flow (liters)		3320703.14
total kjeldahl nitrogen (mg/l)	<	14.9326481
Ammonia (mg/l)	<	12.3279828
biological oxygen demand (mg/l)	<	31.0383802
chemical oxygen demand (mg/l)	<	106.50845
total suspended solids (mg/l)	<	59.2000676
oil and grease (mg/l)	<	3.86843763
arsenic (mg/l)	<	0.04
boron (mg/l)		0.03796437
cadmium (mg/l)	<	0.0032
chlorinated hydrocarbons (mg/l)	<	0.0495773
hexavalent chromium (mg/l)	<	0.05275679
total chromium (mg/l)	<	0.00604501
copper (mg/l)		0.0227603
cyanide (mg/l)		0.01233572
lead (mg/l)	<	0.02
iron (mg/l)		0.45189077
manganese (mg/l)	<	0.13370174
mercury (mg/l)	<	0.0013883
nickel (mg/l)	<	0.0072
phenols (mg/l)	<	0.01495406
selenium (mg/l)	<	0.00178667
silver (mg/l)	<	0.00438572
zinc (mg/l)		0.18521807
gross alpha (pci/l)		43.1183517
gross beta (pci/l)		55.4107017
gross gamma (pci/l)		108.821025

Total Radionuclides Releases from January 1990 to June 1991

		Average	Ci/year
flow (ft3)		213893	
Alpha acitivity (pCi/l)		18.1	0.040031
Beta activity (pCi/l)		29.3	0.064855
Gamma activity (pCi/l)		188.7	0.417147
		Total	0.522033

The Question of Uranium-233 in The Sanitary Sewer System.

The following calculations were performed by the Y-12 Radiological Engineering Section in response to inquiries concerning the amounts of Uranium-233 in the sanitary sewer and whether or not the Y-12 Plant was in compliance with the provisions for Sanitary Sewer Discharges outlined in DOE Order 5400.5, "Radiation Protection of the Public and the Environment."

1) DOE Order 5400.5, Section II.3.d, addresses "Discharges of Liquid Waste to Sanitary Sewerage."

> "The BAT selection process shall be implemented if liquid wastes discharged from DOE activities into sanitary sewerage contain radionuclides at concentrations, averaged monthly, would otherwise be greater that five times the DCG values for liquids given in Chapter III at the point of discharge. That is, the BAT selection process shall be implemented if the total of the fractions of the average concentrations for each radionuclide to its respective DCG value would otherwise exceed 5.

2) DOE Order 5400.5, Section III, Figure III-1, lists "Derived Concentration Guides (DCGs) for Members of the Public from Ingested Water and Inhalation Resulting in 100 mrem/y." Values for Ingested water containing Uranium are as follow:

U-233	5×10^{-7} μCi/ml	for D and W class
	5×10^{-6} μCi/ml	for Y class

Using the most restrictive DCG of 5×10^{-7} μCi/ml, 5 times the DCG is 2.5×10^{-6}.
Thus, 2.5×10^{-6} μCi/ml is the value, below which BAT does not have to be applied.

2) The U-233 content in the Sanitary Sewer Discharges from the Y-12 Plant, as reported in the 22-Aug-1991 letter from L. E. White to K. G. Hanzelka was 1.45×10^{-13} grams/liter.

3) Calculating the curie concentration discharge using the specific activity of U-233 yields:

$(9.48 \times 10^{-3}$ Ci/g) x $(1.45 \times 10^{-13}$ g/l) x $(10^{6}$ μCi/Ci) x $(l/10^{3}$ ml) = 1.37×10^{-12} μCi/ml

4) Thus, the concentration of U-233 in the Y-12 discharge to the Sanitary Sewer is approximately six orders of magnitude below the 2.5×10^{-6} μCi/ml specified by DOE Order 5400.5.

The Question of Plutonium in The Sanitary Sewer System.

The following calculations were performed by the Y-12 Radiological Engineering Section in response to inquiries concerning the amounts of Plutonium in the sanitary sewer and whether or not the Y-12 Plant was in compliance with the provisions for Sanitary Sewer Discharges outlined in DOE Order 5400.5, "Radiation Protection of the Public and the Environment."

1) DOE Order 5400.5, Section II.3.d, addresses "Discharges of Liquid Waste to Sanitary Sewerage."

> "The BAT selection process shall be implemented if liquid wastes discharged from DOE activities into sanitary sewerage contain radionuclides at concentrations, averaged monthly, would otherwise be greater that five times the DCG values for liquids given in Chapter III at the point of discharge. That is, the BAT selection process shall be implemented if the total of the fractions of the average concentrations for each radionuclide to its respective DCG value would otherwise exceed 5.

2) DOE Order 5400.5, Section III, Figure III-1, lists "Derived Concentration Guides (DCGs) for Members of the Public from Ingested Water and Inhalation Resulting in 100 mrem/y." Values for Ingested water containing Uranium are as follow:

Pu-238	4×10^{-8} μCi/ml	for D and W class
	3×10^{-6} μCi/ml	for Y class.
Pu-239/240	3×10^{-8} μCi/ml	for D and W class
	2×10^{-6} μCi/ml	for Y class.

Using the most restrictive DCG for each isotope and multiplying by 5 yeilds results, below which BAT need not be applied of:

Pu-238	2×10^{-7} μCi/ml
Pu-239/240	1.5×10^{-7} μCi/ml

3) Analytical Data for samples collected on July 13 and July 21, 1991 were as follows:

	July 13, 1991	July 21, 1991
Pu-238	0.15 +/- 0.14 pCi/l	0.10 +/- 0.18 pCi/l
Pu-239/240	-0.02 +/- 0.03 pCi/l	0.08 +/- 0.13 pCi/l

4) Using a conversion factor from pCi/l to μCi/ml of 10^{-9} and the largest result from the analytical data, the following concenrations are obtained:

Pu-238	$(0.15+0.14)$ pCi/l $\times 10^{-9} = 2.9 \times 10^{-10}$ μCi/ml
Pu-239/240	$(0.08+0.13)$ pCi/l $\times 10^{-9} = 2.1 \times 10^{-10}$ μCi/ml

5) Thus, the concentration of plutonium in the Y-12 discharge to the Sanitary Sewer is approximately three orders of magnitude below the 2×10^{-7} μCi/ml and 1.5×10^{-7} μCi/ml specified by DOE Order 5400.5.

I N T E R O F F I C E M E M O R A N D U M

Date: 22-Aug-1991 02:51pm EI
From: Lewis E White
WHITELE AT A1 AT OCB1
Dept: 2365
Tel No: (615) 574 2904

TO: Hanzelka, Kim G (HANZELKAKG AT A1 AT OCU)

CC: Ronald J McElhaney (MCELHANEYRJ AT A1 AT OCB1)
CC: Nanney, Joseph C (NANNEYJC AT A1 AT OCU)
Subject: U233 in Sanitary Sewer Sample

Kim,

Dave Smith has completed his analysis on the sanitary sewer sample we submitted for U233 and Pu.

Our lab prepared the sample for ORNL in a hood away from the usual mass spec prep area to make sure that there was no cross contamination with our U233 spiking solution.

Dave did find U233 present in the sample. The level was so low, however, that we would have had a hard time seeing it by our normal alpha spec method.

The sample contained 5 micrograms of uranium per liter of solution per our labs previous analyses. The ORNL mass spec saw 29 ppm U233 in the uranium present.

Since I don't have a minus sign on my word processor, I can't generate a negative exponental number. For this sample please add the negative exponent where I have a *.

The total uranium for this sample would be 5 X 10*9 grams U per liter.

The U233 would be 2.9 X10*5 grams U233/ gram of uranium.

So the concentration of U233 in the sample would be 1.45 X 10*13 grams per liter (based on atom percent uranium).

Dave Smith was quite happy with how the sample ran and would be more than happy to provide additional analyses as you see fit.

Dave also looked for plutonium in the sample. His ratio with the uranium was approximately 9 ppm Pu. There is the possibility that because the plutonium level so closely mirrored the uranium data that he was actually looking at UH+. The uranium hydride ion would have about the same mass as the plutonium so it is difficult to say if anything is really there.

Please let me know if you want additional samples analyzed of if any of the above data needs further explanation.

Thanks,

Ed White

APPENDIX O

U.S. Department of Energy

Washington, D.C.

ORDER

DOE 5400.5

2-8-90

SUBJECT: RADIATION PROTECTION OF THE PUBLIC AND THE ENVIRONMENT

1. PURPOSE. To establish standards and requirements for operations of the Department of Energy (DOE) and DOE contractors with respect to protection of members of the public and the environment against undue risk from radiation.

2. SUPERSESSION. DOE 5480.1A, ENVIRONMENTAL PROTECTION, SAFETY, AND HEALTH PROGRAM FOR DOE OPERATIONS, of 8-13-81, Chapter XI that addressed public and environmental radiation protection standards and control practices.

3. SCOPE. The provisions of this Order apply to all Departmental Elements and contractors performing work for the Department as provided by law and/or contract and as implemented by the appropriate contracting officer.

4. IMPLEMENTING PROCEDURES AND REQUIREMENTS. This Order becomes effective 3 months from the date of issuance. Within 1 month from the date of issuance of the Order, Heads of Operations Offices shall provide to the appropriate Program Office with copy to EH-1 for review and comment: (1) a certification for those areas covered by the Order for which Site/Operations Offices are in compliance; and/or (2) a request for exemption for areas of non-compliance that includes a Plan for achieving compliance. Within 2 months of issuance, the appropriate Program Office will submit to EH-1 the certification and/or the request for exemption(s). The compliance plan shall include schedules for achieving compliance with the requirements of this Order within 3 months after issuance of this Order.

5. POLICY. It is the policy of DOE to implement legally applicable radiation protection standards and to consider and adopt, as appropriate, recommendations by authoritative organizations, e.g., the National Council on Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP). It is also the policy of DOE to adopt and implement standards generally consistent with those of the Nuclear Regulatory Commission (NRC) for DOE facilities and activities not subject to licensing authority.

6. OBJECTIVES.

   a. Protecting the Public. It is DOE's objective to operate its facilities and conduct its activities so that radiation exposures to members of the public are maintained within the limits established in this Order and to control radioactive contamination through the management of real and personal property. It is also a DOE objective that potential exposures to members of the public be as far below the limits as is reasonably achievable (ALARA) and that DOE facilities have the capabilities, consistent with the types of operations conducted, to monitor routine and non-routine releases and to assess doses to members of the public.

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sites. These requirements are intended to prevent the buildup of contamination in soils and ground water and to protect the environment from the spread of contamination from burial trenches and pits.

7. DISCHARGES TO SANITARY SEWERAGE. The control of releases of liquid wastes to community sanitary sewer systems is designed to be generally consistent with requirements imposed by NRC on its licensees. As discussed in Chapter II, the "best available technology" (BAT) selection process is to be applied to the treatment of liquid wastes released to sanitary sewerage when concentrations of radionuclides would otherwise exceed five times the DCG reference values given in Chapter III. Operators should ensure that the total annual discharge of radioactive material to the sanitary sewer system will not cause exposures to members of the general public that will result in doses exceeding a small fraction of the basic annual dose limit.

8. EFFLUENT MONITORING AND ENVIRONMENTAL SURVEILLANCE.

   a. Demonstration of Compliance. Demonstrations of compliance with requirements of this Order generally will be based upon calculations that make use of information obtained from monitoring and surveillance programs. The abilities to detect, quantify, and adequately respond to unplanned releases of radioactive material to the environment also re on in-place effluent monitoring, monitoring of environmental transport and diffusion conditions, and assessment capabilities. This will enable DOE to develop useful data and to collect and analyze pertinent information on unplanned releases in a timely manner. It is the intent of DOE that the monitoring and surveillance programs for the DOE activities, facilities, and locations be of high quality. Although some differences result from specific site or specific activity conditions, uniformity in the methods and performance criteria used in obtaining the information is desirable.

   b. Monitoring and Surveillance Requirements. To ensure that the effluent monitoring and environmental surveillance programs are of good quality at all DOE facilities and sites, certain requirements and recommendations are provided in DOE Orders in the 5400 series which deal with radiological effluent monitoring and environmental surveillance.

9. RESIDUAL RADIOACTIVE MATERIAL. DOE practices and requirements for residual radioactive material are presented in Chapter IV, including limits of potential dose, authorized contamination limits for the release of property, and ALARA considerations.

10. DOSE EVALUATIONS

   a. Standard Methods. Data developed by the Department to demonstrate that DOE operations comply with applicable standards and requirements shc ld be correct and representative. Accordingly, this Order requires th.. calculations of dose to the public from exposures resulting from both

Radionuclide	f_1 Value	Ingested Water DCG (μCi/mL)	Inhaled Air DCG (μCi/mL) D	W	Y
Th-226	2.E-04	1.E-04	-	4.E-10	3.E-10
Th-227	2.E-04	4.E-06	-	8.E-13	7.E-13
Th-228	2.E-04	4.E-07	-	5.E-14	4.E-14
Th-229	2.E-04	4.E-08	-	6.E-15	7.E-15
Th-230	2.E-04	3.E-07	-	4.E-14	5.E-14
Th-231	2.E-04	1.E-04	-	1.E-08	2.E-08
Th-232	2.E-04	5.E-08	-	7.E-15	1.E-14
Th-234	2.E-04	1.E-05	-	5.E-10	4.E-10
Th-Natural	2.E-04	5.E-08	-	7.E-15	1.E-14
Pa-227	1.E-03	1.E-04	-	3.E-10	2.E-10
Pa-228	1.E-03	3.E-05	-	5.E-11	3.E-11
Pa-230	1.E-03	2.E-05	-	1.E-11	8.E-12
Pa-231	1.E-03	1.E-08	-	9.E-15	1.E-14
Pa-232	1.E-03	4.E-05	-	1.E-10	2.E-10
Pa-233[3]	1.E-03	4.E-05	-	2.E-09	1.E-09
Pa-234[3]	1.E-03	7.E-05	-	2.E-08	2.E-08
U-230	5.E-02	2.E-07	1.E-12	8.E-13	-
	2.E-03	1.E-06	-	-	6.E-13
U-231	5.E-02	1.E-04	2.E-08	1.E-08	-
	2.E-03	1.E-04	-	-	1.E-08
U-232	5.E-02	1.E-07	1.E-12	9.E-13	-
	2.E-03	2.E-06	-	-	2.E-14
U-233	5.E-02	5.E-07	4.E-12	2.E-12	-
	2.E-03	5.E-06	-	-	9.E-14
U-234	5.E-02	5.E-07	4.E-12	2.E-12	-
	2.E-03	5.E-06	-	-	9.E-14
U-235	5.E-02	6.E-07	5.E-12	2.E-12	-
	2.E-03	5.E-06	-	-	1.E-13
U-236	5.E-02	5.E-07	5.E-12	2.E-12	-
	2.E-03	6.E-06	-	-	1.E-13
U-237	5.E-02	5.E-05	6.E-09	4.E-09	-
	2.E-03	5.E-05	-	-	4.E-09
U-238	5.E-02	6.E-07	5.E-12	2.E-12	-
	2.E-03	6.E-06	-	-	1.E-13
U-239[3]	5.E-02	2.E-03	4.E-07	4.E-07	-
	2.E-03	2.E-03	-	-	4.E-07
U-240	5.E-02	3.E-05	9.E-09	7.E-09	-
	2.E-03	3.E-05	-	-	6.E-09
U-Natural	5.E-02	6.E-07	5.E-12	2.E-12	-
	2.E-03	6.E-06	-	-	1.E-13
Np-232	1.E-03[6]	6.E-03[7]	-	1.E-08[8]	-

Figure III-1 (contd)

Radionuclide	f_1 Value	Ingested Water DCG (μCi/mL)	Inhaled Air DCG (μCi/mL) D	W	Y
Np-233	1.E-03[6]	2.E-02[7]	-	8.E-06[8]	-
Np-234	1.E-03[6]	8.E-05[7]	-	6.E-09[8]	-
Np-235	1.E-03[6]	6.E-04[7]	-	3.E-09[8]	-
Np-236 (1.E+05 yr)	1.E-03[6]	2.E-07[7]	-	1.E-13[8]	-
Np-236 (22 h)	1.E-03[6]	1.E-04[7]	-	2.E-10[8]	-
Np-237	1.E-03[6]	3.E-08[7]	-	2.E-14[8]	-
Np-238	1.E-03[6]	4.E-05[7]	-	4.E-10[8]	-
Np-239[3]	1.E-03[6]	5.E-05[7]	-	5.E-09[8]	-
Np-240[3]	1.E-03[6]	7.E-04[7]	-	2.E-07[8]	-
Pu-234	1.E-03[6]	1.E-04[7]	-	5.E-10[8]	-
	1.E-05[6]	2.E-04[7]	-	-	4.E-10[8]
Pu-235	1.E-03[6]	1.E-02[7]	-	7.E-06[8]	-
	1.E-05[6]	2.E-02[7]	-	-	6.E-06[8]
Pu-236	1.E-03[6]	1.E-07[7]	-	8.E-14[8]	-
	1.E-05[6]	5.E-06[7]	-	-	9.E-14[8]
Pu-237	1.E-03[6]	1.E-04[7]	-	8.E-09[8]	-
	1.E-05[6]	3.E-04[7]	-	-	7.E-09[8]
Pu-238	1.E-03[6]	4.E-08[7]	-	3.E-14[8]	-
	1.E-05[6]	3.E-06[7]	-	-	4.E-14[8]
Pu-239	1.E-03[6]	3.E-08[7]	-	2.E-14[8]	-
	1.E-05[6]	2.E-06[7]	-	-	4.E-14[8]
Pu-240	1.E-03[6]	3.E-08[7]	-	2.E-14[8]	-
	1.E-05[6]	2.E-06[7]	-	-	4.E-14[8]
Pu-241	1.E-03[6]	2.E-06[7]	-	1.E-12[8]	-
	1.E-05[6]	1.E-04[7]	-	-	2.E-12[8]
Pu-242	1.E-03[6]	3.E-08[7]	-	2.E-14[8]	-
	1.E-05[6]	2.E-06[7]	-	-	4.E-14[8]
Pu-243	1.E-03[6]	4.E-04[7]	-	8.E-08[8]	-
	1.E-05[6]	4.E-04[7]	-	-	9.E-08[8]
Pu-244	1.E-03[6]	3.E-08[7]	-	2.E-14[8]	-
	1.E-05[6]	2.E-06[7]	-	-	4.E-14[8]
Pu-245	1.E-03[6]	6.E-05[7]	-	1.E-08[8]	-
	1.E-05[6]	6.E-05[7]	-	-	1.E-08[8]
Am-237	1.E-03[6]	2.E-03[7]	-	7.E-07[8]	-
Am-238	1.E-03[6]	8.E-04[7]	-	1.E-08[8]	-
Am-239	1.E-03[6]	1.E-04[7]	-	3.E-08[8]	-
Am-240	1.E-03[6]	5.E-05[7]	-	6.E-09[8]	-
Am-241	1.E-03[6]	3.E-08[7]	-	2.E-14[8]	-
Am-242m	1.E-03[6]	3.E-08[7]	-	2.E-14[8]	-
Am-242	1.E-03[6]	1.E-04[7]	-	2.E-10[8]	-
Am-243	1.E-03[6]	3.E-08[7]	-	2.E-14[8]	-

Figure III-1 (contd)

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